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RETHINKING *Eucalyptus globulus* Labill. BASED LAND USE SYSTEMS IN SMALLHOLDER FARMERS LIVELIHOODS: A CASE OF KOLOBO WATERSHED, WEST SHEWA, ETHIOPIA

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Abstract

Feyisa D., Kissi E., Kebebew Z.: Rethinking *Eucalyptus globules* Labill. based land use systems in smallholder farmers livelihoods: a case of Kolobo Watershed, West Shewa, Ethiopia. Ekológia (Bratislava), Vol. 37, No. 1, p. 57–68, 2018.

Despite their restriction, smallholder farmers have been continuing growing *Eucalyptus globulus* in the cultivated land in the central highland of Ethiopia. Literature has shown controversial issues against *E. globulus*. Therefore, the objective of the study was to investigate the compatibility of *E. globulus* in the smallholder farmers' land use system. Soil samples were collected from five different land uses and analysed for selected physical and chemical properties. The socioeconomic contribution of *E. globulus* was collected through household surveys from 110 households. Analysis of soil showed that organic carbon (OC), total nitrogen (TN) and cation exchange capacity (CEC) were significantly higher ($P<0.05$) under *E. globulus* compared to the cultivated land. The survey results also showed that the largest proportion (58%) of households was interested in growing *E. globulus* because of its multiple uses. About 83% of households responded that *E. globulus* help them to attain food security through increasing the purchasing power of smallholder farmers to buy agricultural inputs and food. This study has substantiated the role of *E. globulus* in the land use system of smallholder farmers. Most of the soil fertility indicators were better under *E. globulus*. The present finding reveals that *E. globulus* degrade the soil seemingly difficult to generalise. Growing *E. globulus* must be promoted under appealing land use to enhance smallholder farmers' livelihoods. Removing *E. globulus* from the land use system may jeopardise the food security situation of many households.

Key words: land use systems, farm forestry, soil fertility, rural livelihoods, socioeconomics.

Introduction

Tree-based land use is mainly the pathway of farming practices change that smallholder farmers undertake to improve their livelihoods (Newby et al., 2014). Many studies indicate that tree is a vital component of land use system that sustains rural livelihoods (Pretzsch, 2005). To this effect, smallholder farmers widely plant *Eucalyptus globulus* in various spatial patterns as component of land use in central highlands of Ethiopia (Mekonnen, 2000). An experience from Arsi Negelle in Ethiopia shows that about 11% of cropland has been converted to growing *Eucalyptus* woodlots (Jenbere et al., 2012).

Land is the fundamental component of production in Ethiopia (Teshome et al., 2014) that supports millions of the rural population particularly through agriculture (Mekuria, Aynekulu, 2011). The fear of displacing agricultural crops and the detrimental environmental effect has raised debate over growing *E. globulus* (Yitaferu et al., 2013). *Eucalyptus* has been alleged that it affects the physical and chemical properties of soil that leads the Oromia regional state to enact rural land use and administration (proclamation number 56/2002) that discourage growing *Eucalyptus* on cropland as agriculture is the means of livelihood (Kebebew, Ayele, 2010).

Smallholder farmers' agriculture is believed to tackle food security in the country (Negra et al., 2014). Nevertheless, land degradation coupled with climate change constraints agricultural production at subsistence (Karltun et al., 2013). This bring about millions of the population have failed to attain food security and suffered from severe shortage of food (Karltun et al., 2013). Smallholder farmers undertake farming practices change as an option to keep their livelihood sustenance (Kristjanson et al., 2012; Negra et al., 2014). In Ethiopia, rehabilitation of degraded land has taken attention to increase agricultural production, better off the household well-being. The farmers' experience depicts growing *Eucalyptus* as an innovative land use approach to normalise the land benefits (Negra et al., 2014).

Despite the controversy over *Eucalyptus*, there are no concrete empirical evidence that validates the detrimental effect of *Eucalyptus* on food security and livelihoods (Kidanu et al., 2005; Duguma et al., 2010; Yitaferu et al., 2013; Haile et al., 2014). In Ethiopia, food security is supposed to be addressed through increased agricultural production (Diao, Pratt, 2007; Van der Veen, Tagel, 2011). In contrast, this type of farming requires purchasing power of inputs. However, because of the nature of farming system (Abebaw et al., 2010) smallholder farmers have the limitation of purchasing power. The apparent experience is to undertake land use activities that complement agricultural production (Teshome et al., 2014). Growing *Eucalyptus* is one form of the land use that helps smallholder to sustain the livelihoods (Jenbere et al.; 2012, Duguma, Hager, 2011). For the rural people, *Eucalyptus* is a means of safety net (Kebebew, Ayele, 2010). Even if the policy makers discourage growing *E. globulus* on farm, smallholder farmers in the central highlands of Ethiopia have continued growing *E. globulus* as one component of land use (Kebebew, Ayele, 2010). The objective of the study was to investigate compatibility of *E. globulus* under smallholder farmers. This paper tries to answer the following research questions:

- Does the rate of change of soil go beyond the optimum soil fertility?
- How does *E. globulus* fit into smallholder farmers land use option in context of food security?

Material and methods

The study was conducted in Kolobo watershed, Adea Berga district of the west Shewa zone, Oromia, Ethiopia. The area where the study is conducted is about 250 ha. The district is located at a distance of 74 km from Addis Ababa on the way to Mogor Cement Enterprise. Geographically, it is located between 9°12′ to 9°37′N and 38°17′ to 38°36′E. The altitude of the area ranges from 1,500 to 3,180 m a.s.l. with an average annual temperature ranges from 15 to 25.5 °C. The annual rainfall of the study area goes up to 1,400 mm. The main rainy season is from June to September and August is the peak rainy month (Kidanu et al., 2005).

Land use complementary effect of *E. globulus* was investigated through assessing soil properties and socioeconomic benefits. Data was collected from September 2013 to April 2014. A reconnaissance survey was carried out and five land use types were chosen. Under farmers' experience, *Eucalyptus* is mostly harvested starting from year four (Kidanu et al., 2005). Hence, age of *E. globulus* was fixed at year four. To minimise soil properties variation because of the slope of the land, first, the area was divided into similar slope category (bottom 2–5%, middle slope 6–9%, top slope >9%) and five different homogeneous land uses were selected from middle slope category. The elevation is about 2,700 m a.s.l. Vertisols dominates the area. Land use history shows the land is used for growing barely, wheat, teff, beans and peas at different time. Next plot of size 20×20 m with three replicates from each land use types was identified. Within a plot, five different points (2×2 m) were selected, dug to the depth of 30 cm and finally collected soil sample per plot were composited to get one sample. A total of 15 soil samples were backed in plastic bags and transported to laboratory for analysis. Similar study approach was used by Duguma et al. (2010), Abbasi et al. (2007) and Jenbere et al. (2012).

Collected soil samples were air dried, mixed and passed through a 2-mm sieve for the analysis of selected soil physical and chemical properties at the Jimma University College of Agriculture soil laboratory. Soil texture, bulk density and moisture content were analysed for soil physical properties, whereas soil pH, electrical conductivity (EC), organic carbon (OC), organic matter (OM), total nitrogen (TN), availability of phosphorous (Av.P), cation exchange capacity (CEC) and exchangeable bases were analysed for soil chemical properties. Laboratory analysis was conducted following standard procedures of soil physical and chemical analysis.

Soil texture was analysed following the Boycouos hydrometric method (Abbasi et al., 2007). Hydrogen peroxide (H_2O_2) was first added to destroy OM and then sodium hexametaphosphate $(NaPO_3)_6$ was added to disperse the soil. Soil textural classes were determined using the USDA triangular guideline (Brady, Weil, 2002). Soil bulk density was determined by core method after drying the soil samples in an oven at 105 °C following Abbasi et al. (2007) and Sahlemedhin and Taye (2000). Soil moisture content was measured using gravimeter method as described by Sahlemedhin and Taye (2000).

Soil pH-H_2O and EC were estimated from soil-to-water ratio of 1:2.5 and 1:5, respectively (Sahlemedhin, Taye, 2000). The reading of pH was taken by pH meter, whereas EC was measured by electrical conductivity meter. The soil OC was measured by the Walkley–Black oxidation method with potassium dichromate ($K_2Cr_2O_7$) in a sulphuric acid and converted to soil OM by multiplying it by the factor of 1.724 as described by Nelson and Sommers (1982). TN was determined by the Kjeldahl methods and available phosphorus was determined using the Bray II extraction method (Van Reeuwijk, 1992).

Total exchangeable bases were determined after leaching the soils with ammonium acetate. Amounts of Ca^{2+} and Mg^{2+} in the leachate were analysed by atomic absorption spectrophotometer (AAS) and K^+ and Na^+ was analysed using flame photo metrically (Chapman, 1965). CEC was determined at soil pH level of 7 after the displacement by using 1N ammonium acetate method and then estimated titrimetrically by distillation of ammonium that was displaced by sodium (Chapman, 1965). Percent base saturation (PBS) was calculated by dividing the sum of the base-forming cations (Ca, Mg, Na and K) by the CEC of the soil and multiplying it by 100 (Fageria, 2009).

Structured and semi-structured questionnaires were prepared and pretested to collect the socioeconomic information. The household survey focused on *E. globulus* and land use under farmers' circumstances. A list of all households living (N = 561) in the watershed was obtained with the help of local administrative bodies (development agents). A sample size was determined using the Cochran (1977) formula. Based on the formula, a total of 110 households were randomly selected for the interview. The information was collected through face-to-face interview with all households (n = 110) at their convenient time. Each household was categorised as rich, medium and poor in the *kebele*. The local administrative body has the record of the wealth status of every household for any development activities. Hence, wealth status of the household was recorded based on the local administrative record. Cost of the fertiliser and income from the *Eucalyptus* took into account the actual farmer experience. Annual production and productivity of agricultural crops were estimated in quintal {metric} (1quintal {metric}= 100 kg). Farm gate price, cost of fertilisers and income from *Eucalyptus* were estimated in local currency (1 ETB= $ 0.049 USD). It must be known that income from *Eucalyptus* was collected only on actual income from *Eucalyptus* sales of farmers' experience. The information obtained through household survey were triangulated through focus group discussion (with development agent and expert from district agricultural bureau) and key informant interview (with local elders). Collected information was organised, coded and finally analysed.

Soil physico-chemical properties were analysed using one way analysis of variance (ANOVA). Before the analysis, the data was checked for the assumption of ANOVA. ANOVA was run using SAS software (SAS, 9.2). For variables showing statistically significant difference between treatments ($p < 0.05$), analysis of mean separation was carried out using least significant difference (LSD) at 5% probability. The socioeconomic data was analysed using descriptive and inferential statistics using SPSS version 20.

Results and discussion

Soil physical properties

Soil texture, bulk density and moisture were analysed for soil physical properties. The result showed significant difference ($P < 0.005$) amongst land use types (Tables 1 and 2). Soil under forest, *E. globulus*, cultivated and grazing land had clay texture, whereas degraded land had clay loam texture. The proportion of clay was highest (56%) under forest and lowest (27%) under degraded land. Soil under *E. globulus* had significantly higher proportion of clay particles (48%) than grazing (41%) and degraded land (27%). Although the proportion of clay under *E. globulus* and culti-

T a b l e 1. Mean ± SEM values for soil textural properties under five land use types.

Land use	**Clay (%)**	**Sand (%)**	**Silt (%)**	**Textural class**
Forest	55.67 ± 1.76^{a}	21.00 ± 3.33^{cd}	21.33 ± 4.67^{b}	Clay
E. globulus	47.67 ± 1.76^{b}	29.00 ± 3.06^{bc}	23.33 ± 4.06^{b}	Clay
Cultivated	41.67 ± 2.40^{bc}	35.33 ± 4.06^{ab}	24.00 ± 4.00^{b}	Clay
Grazing	41.00 ± 1.15^{c}	15.33 ± 2.40^{d}	43.67 ± 3.53^{a}	Clay
Degraded	27 ± 2.31^{d}	42.67 ± 2.40^{a}	30.33 ± 4.67^{ab}	Clay loam
PV	0.0001	0.0027	0.0417	-
LSD (0.05)	6.58	10.83	15.17	-
CV (%)	8.20	20.15	22.18	-

Notes: PV – p value; CV – coefficient of variance; LSD – least significant difference; SEM – standard error mean.

T a b l e 2. Mean ± SEM values for SMC and BD under different land use types.

Land use	**SMC (%)**	**BD (g cm^{-3})**
Forest	34.37 ± 1.78^{a}	0.97 ± 0.02^{b}
E. globulus	17.64 ± 0.55^{c}	0.87 ± 0.05^{c}
Cultivated	18.97 ± 0.87^{c}	1.14 ± 0.01^{a}
Grazing	26.67 ± 0.85^{b}	1.01 ± 0.01^{b}
Degraded	12.89 ± 0.57^{d}	1.10 ± 0.02^{a}
PV	<0.0001	0.0002
LSD (0.05)	3.56	0.07
CV (%)	8.56	3.75

Notes: SMC – soil moistures content; BD – bulk density; PV – p value; CV – coefficient of variance; LSD – least significant difference; SEM – standard error mean.

vated land was not significantly different, in terms of magnitude, there was a higher proportion of clay under *E. globulus* (48%) than cultivated land. The clay fraction under *E. globulus* was higher when compared to cultivated land. This might be due to high vegetation cover that reduces the clay fractions likely to be lost by selective erosion processes. Clay particles are removed and transported easily than sand particle (Selassie et al., 2015). Those agree with the findings of Lemenih et al. (2005) who had reported high clay content under *E. globulus* plantation as compared to cultivated and grazing land. This means that soils under *E. globulus* are more fertile than those of cultivated and degraded land.

Soil under *E. globulus* had the lowest bulk density (0.87 g cm^{-3}) as compared to other land use types. Cultivated land had the highest bulk density (1.14 g cm^{-3}). The lower bulk density under *E. globulus* implies that the soil is less compacted. The optimum range of bulk density of agricultural soil is between 0.9 and 1.2 g cm^{-3} (Frank, 1990). The result shows that soil under *E. globulus* is within the range of the optimum condition for agriculture (0.87--1.14 g cm^{-3}) (Table 2). According to Miller and Donahue (1997), bulk densities need to be below 1.4 g cm^{-3} for good plant growth. Yitaferu et al. (2013) had reported lower bulk density (1.07 g cm^{-3}) under *Eucalyptus* compared to cultivated land (1.11 g cm^{-3}) in west Gojam Amhara regional state, Ethiopia. Similarly, Selassie and Ayanna (2013), Getachew et al. (2012) and Haile et al. (2014) had reported lower soil bulk density under *Eucalyptus* compared to cultivated land. The present results agree with the previous findings on the same.

Soil moisture content results showed significant difference under different land use types ($P < 0.05$). Soil under forest had the highest (34%) and degraded land had the lowest soil moisture (13%). Soil moisture under *E. globulus* (18%) was lower compared to that under the forest (34%), under grazing (27%), of cultivated land (18%) but greater than that under degraded land (12%). Although the absolute value of soil moisture under *E. globulus* was lower than the cultivated land, the results were not significantly different at $P > 0.05$ (Table 2). This is probably attributed to short rotation age of *E. globulus* (4 years). These findings are in agreement with similar study report by Selassie and Ayanna (2013), Getachew et al. (2012) and Haile et al. (2014) who had reported no significant difference on the same between *E. globulus* and cultivated land.

Soil chemical properties

Soil under *E. globulus* had significantly ($P < 0.05$) lower pH value (5.55) compared to other land use types. Owing to high cation uptake and low accumulation of exchangeable bases, soil under *E. globulus* had lower EC (0.025ds/m) compared to others (Table 3). Table 4 shows positive and significant correlation between EC and soil pH ($r = 0.85$), Mg^{2+} ($r = 0.63$) and Ca^{2+} ($r = 0.63$). The finding agrees with Haile et al. (2014) who had reported lower pH value under *Eucalyptus* woodlots compared to other land use types. However, the pH value (5.55) of this study is greater than that previous report by Selassie and Ayanna (2013) who reported pH values of 5.06 and 5.01 under the *E. globulus* at Abechikeli Mariam and Aferfida Georgis sites, respectively. Duguma et al. (2010) also reported a lower pH value (5.06) under *E. globulus* compared to homestead, croplands and grazing lands at central highlands of Ethiopia. The higher pH (5.55) value of this finding compared to the previous findings is probably attributed to the age of the *Eucalyptus* as the sample soil was taken under 4 years older *Eucalyptus*. According to Frank (1990), the pH values of most

T a b l e 3. Mean ± SEM values for soil pH and EC under different land use systems.

Land use	pH	EC (ds/m)
Forest	6.52 ± 0.11[a]	0.045 ± 0.0028[a]
E. globulus	5.55 ± 0.14[b]	0.025 ± 0.0028[c]
Cultivated	6.29 ± 0.25[a]	0.032 ± 0.004[bc]
Grazing	6.28 ± 0.09[a]	0.037 ± 0.0015[ab]
Degraded	5.60 ± 0.16[b]	0.029 ± 0.003[bc]
PV	0.007	0.003
LSD (0.05)	0.52	0.01
CV (%)	4.58	13.16

Notes: pH – power of hydrogen; EC – electrical conductivity; PV – p value; CV – coefficient of variance; LSD – least significant difference.

T a b l e 4. Pearson correlation matrix for the selected soil properties.

	pH	EC	OC	TN	AvP	Ca	Mg	Na	K	CEC
pH	1									
Ec	0.86**	1								
OC	0.53*	0.54*	1							
TN	0.33	0.41	0.94**	1						
AvP	0.74**	0.66**	0.66**	0.63*	1					
Ca	0.64*	0.63*	0.84**	0.75**	0.75**	1				
Mg	0.63*	0.72**	0.80**	0.72**	0.77**	-0.74**	1			
Na	0.36	0.49	0.60*	0.61*	0.18	-0.38	-0.43	1		
K	0.75**	0.67**	0.66**	0.62*	0.99**	-0.75**	0.77**	0.19	1	
CEC	0.46	0.47	0.93**	0.94**	0.72**	0.91**	-0.75**	0.50	-0.72**	1

Notes: pH – power of hydrogen; EC – electrical conductivity; OC – soil organic carbon; TN – total nitrogen; AvP – available phosphorous; Ca – calcium; Mg – magnesium; Na – sodium; K – potassium; CEC – cation exchange capacity; ** Correlation is significant at the 0.01 level (two-tailed); *Correlation is significant at the 0.05 level (two-tailed).

T a b l e 5. Mean ± SEM values for OC, OM, TN and Av.P under different land use systems.

Land use	OC (%)	OM (%)	TN (%)	Av.P (ppm)
Forest	3.05 ±0.22[a]	5.27 ± 0.37[a]	0.31 ± 0.02[a]	5.71 ± 0.48[a]
E. globulus	2.02 ± 0.28[b]	3.47 ± 0.49[b]	0.25 ± 0.04[b]	2.08 ± 0.41[c]
Cultivated	1.24 ± 0.28[c]	2.13 ± 0.49[c]	0.12 ± 0.02[c]	3.99 ± 0.37[b]
Grazing	2.24 ± 0.15[b]	3.86 ± 0.26[b]	0.19 ± 0.01[b]	2.93 ± 0.68[bc]
Degraded	0.48 ± 0.11[d]	0.82 ± 0.19[d]	0.04 ± 0.01[d]	0.61 ± 0.37[d]
p-v	0.0001	0.0001	0.0001	0.003
LSD (0.05)	0.62	1.07	0.06	1.39
CV (%)	18.26	18.20	15.77	24.22

Notes: OC – soil organic carbon; OM – organic matter; TN – total nitrogen; Av.P – available phosphorous; PV – p value; CV – coefficient of variance; LSD – least significant difference.

agricultural soils are in the range of 5.5–7. The pH value (5.5) under *E. globulus* is under medium rating categories implying that the land is suitable for growing crops from soil pH point of views. The experiences of cropping on the land that has been under *Eucalyptus* plantation in west Gojam Amhara regional state, Ethiopia, verify the same (Yitaferu et al., 2013). This result argues against the detrimental effect of *Eucalyptus* on soil pH, rather soil under *Eucalyptus* plantation has a good potential for cropping.

Soil OC, OM, TN and available phosphorous are presented in Table 5. Significant difference ($P < 0.05$) was observed amongst the land use types. Soil under forest had the highest soil OC, OM, TN and available phosphorous, whereas soil under degraded land had the lowest soil OC, OM, TN and available phosphorous. Soil under *E. globulus* had significantly higher soil OC (2.02%), OM (3.47%) and TN (0.25%) compared to cultivated land. The soil OC and OM under forest and *E. globulus* were rated as medium categories; whereas low under cultivated land. The findings agree with similar studies (Abbasi et al., 2007; Duguma et al., 2010; Getachew et al., 2012; Haile et al., 2014). Abbasi et al. (2007) had reported differences in OM amongst land use types. Getachew et al. (2012) had reported more OC than farmland. Haile et al. (2014) had reported more OM under grassland and woodlot compared to cereal farms. Duguma et al. (2010) had more soil OC and TN under small-scale woodlot than pasturelands and cereal farms. Soil under *E. globulus* had significantly ($P < 0.05$) lower available phosphorous than cultivated land (Table 5). There is positive and significant ($r = 0.74$) relationship between available phosphorous and pH (Table 4). Soil pH influences the availability of phosphorus. Phosphorus fixation takes place at lower pH (Kebede, Raju, 2011). Tisdale et al. (2002) also noted that maximum availability of phosphorus generally occurs in a pH range of 6.0–7. This finding agrees with Getachew et al. (2012), Haile et al. (2014) and Yitaferu et al. (2013) findings on the available phosphorous under *Eucalyptus*. The TN is directly and significantly associated with OC ($r = 0.94$) and CEC ($r = 0.94$) (Table 4). The result is similar to Mengist (2011) who had reported higher soil nitrogen under *E. globulus* compared to cultivated land.

CEC, percentage of base saturation (PBS) and exchangeable Ca, Mg and K were significantly ($P < 0.05$) affected by the land use systems, whereas exchangeable Na was not statistically affected by the land use systems (Table 6). Soil under *E. globulus* had higher CEC value (30.78 Cmol(+)/

T a b l e 6. Mean ± SEM values for CEC, exchangeable bases and PBS under different land use types.

LU	CEC	Ca	Mg	Na	K	Total cation	PBS (%)
	Cmol(+)/kg						
F	37.40 ± 1.65^{a}	18.50 ± 1.21^{a}	8.00 ± 0.58^{a}	0.33 ± 0.01	1.14 ± 0.1^{a}	27.97	74.7 ± 0.79^{a}
E	30.78 ± 0.87^{b}	11.86 ± 1.95^{b}	2.30 ± 1.01^{c}	0.31 ± 0.02	0.42 ± 0.08^{cd}	14.89	48.4 ± 3.21^{c}
C	25.09 ± 0.70^{c}	11.21 ± 0.41^{b}	2.97 ± 0.25^{c}	0.29 ± 0.00	0.80 ± 0.08^{b}	15.27	61 ± 2.74^{b}
G	28.21 ± 1.09^{b}	13.50 ± 0.85^{b}	5.83 ± 0.44^{b}	0.31 ± 0.00	0.60 ± 0.14^{bc}	20.24	71.5 ± 2.00^{a}
D	16.96 ± 1.46^{d}	6.17 ± 0.60^{c}	1.30 ± 0.21^{c}	0.29 ± 0.02	0.14 ± 0.05^{d}	7.90	46.4 ± 2.32^{c}
PV	<0.0001	0.0012	0.0003	0.3512	0.0003		<0.0001
LSD	3.05	3.92	2.04		0.28		7.62
CV (%)	5.84	16.99	20.52	8.94	23.80		6.70

Notes: LU – land use; F – forest; E – *E. globulus*; C – cultivated; G – grazing; CEC – cation exchange capacity; BPS – percentage base saturation; PV– p value; CV – coefficient of variance.

kg) compared to grazing (28.21 Cmol (+)/kg), cultivated land (25.09 Cmol (+)/kg) and degraded land (16.96 Cmol (+)/kg). The CEC ratings under forest and *E. globulus* were high. This variation might be attributed to the high accumulation of OM and high clay percentage under *E. globules* and forest land use types. There is positive and strong significant association between CEC and Clay (r = 0.97) and CEC and OM (r = 0.93) (Table 4). The lowest values of exchangeable Mg and K were also observed under *E. globulus* compared to cultivated land. This study disagrees with Duguma et al. (2010) who had reported higher CEC under cereal farms compared to *Eucalyptus*.

Eucalyptus globulus in land use system of smallholder farmers

E. globulus is an integral element of smallholder farmers' land use system in the study area. Table 7 shows the summary of the household characteristics. The response rate to the questionnaires was 100%. The family size of the household ranges between 2 and 15 with an average of 7 persons, which is higher than of the west Shewa zone, 5.3 persons per household. About 45% of the households belong to medium wealth category. The landholding size per household ranges between 0.25 and 14 ha with an average of 3.4 ha. The average landholding size of the households is more than the west Shewa zone of average landholding size who posses on 1.93 ha. About 55% of the households had the landholding size of less than the average landholding size, whilst only about 22% of the households had the landholding size of more than 5 ha.

Assessment of household land allocation showed that about 46% of land was put under cultivation. Only 16% of the land was put under *E. globulus* showing less displacement of cultivated land for growing *E. globulus*. The rich households planted (1.1 ha) more *E. globulus* as compared to poor (0.66 ha) and medium (0.73 ha) households. The difference was statistically significant as determined by one way ANOVA ($F(2,107) = 5.724$, $P = 0.04$). The largest proportion of households (58%) preferred *E. globulus* because of its multiple uses. Only 22% and 20% of the households prefer *E. globulus* because of its fast growth and easy management, respectively. The need for *E. globulus* showed that households prefer to plant *Eucalyptus* on cultivated land (40%), grazing land (34%) and degraded land (26%). The finding agrees with Jenbere et al. (2012) who had reported the rich households plant *Eucalyptus* more than the poor and medium households.

Analysis of *Eucalyptus* in household food security endeavour shows smallholder farmers' strive to produce more food from what they produce. Table 8 shows crop production and pro-

T a b l e 7. Summary of household characteristics.

HH characteristics	N	Min	Max	Mean	Valid Percent
Age classes(no)	110	27	71	45	100
Family size (no)	110	2	15	7	100
Landholding size(ha)	110	0.25	14	3.4	100
Land under *E. globulus* (ha)	110	0.13	3	0.80	100
Wealth status(no)	110				100.0
Medium	49				44.5
Poor	32				29.1
Rich	29				26.4

ductivity of major crops at household level. The rich households produce, on an average, 18.48 quintal per year. The medium and poor households produce 18.35 and 15.16 quintal per year, respectively. The poor, medium and rich households need 15.22, 16.27 and 16.17 quintal per year, respectively, to support their families. Currently, most households support their families between 9 and 11 months from what they produce implying to buy food crops for the remaining months. Without using the inputs, the annual production was below the bottom line of what is required to support their families. To increase agricultural production, smallholder farmers' use input such as commercial fertilisers. An average poor, medium and rich households need 3247.92, 3545.19 and 3380.20 ETB, respectively, to buy fertilisers (Table 9). This is equivalent to selling, for instances, 4.39, 4.86 and 4.61 quintal of barley, respectively. Smallholder farmers need cash to buy inputs to increase productivity. *E. globulus* is assists to obtain cash for buying inputs and food. A land user can increase agricultural production when *E. globulus* became a component of the land use. Land under *E. globulus* reduced the quantity of fertilisers to be purchased as *E. globulus* does not need fertiliser application. Therefore, smallholder farmers saved some cash which could have been used to purchase commercial fertilisers. Growing *E. globulus* need less labour implying the labour can shift to agricultural production. The absence of *E. globulus* from the land use systems has shifted all food secure households to food insecure because of the fact that 4 quintal is deducted from average production (17.33 quintal) to purchase fertiliser and then 13.33 quintal is less than the average production needed to support family (15.89 quintal). Therefore, restricting smallholder farmers from planting *E. globulus* may negatively affect their livelihoods. *E. globulus*

Table 8. Crops productivity per hectare with and without inputs at household level.

	Wealth categories			
	Poor	**Medium**	**Rich**	**Average**
Average annual production [quintal (metric)] Total production	15.16	18.35	18.48	17.33
Production needed to support family	15.22	16.27	16.17	15.89
Food self sufficiency (months)	9.88	10.65	10.8	
Average productivity per ha [quintal (metric)] Without inputs				
Barley	3.16	4.33	3.59	3.69
Wheat	4.44	4.82	4.5	4.59
Peas	1.19	2.04	2.43	1.89
Beans	2.17	3	3.43	2.87
Teff	3.52	3.47	3.26	3.42
Average	2.89	3.53	3.44	3.29
With inputs				
Barley	15.3	16.3	16.9	16.17
Wheat	19.9	20.2	21	20.37
Peas	3.7	6	6.8	5.5
Beans	6.5	8.9	9.2	8.2
Teff	13.5	14.6	14.2	14.1
Average	11.8	13.2	13.6	12.87

made a substantial contribution to the income of the households, even more than agricultural crops (Selassie, Ayanna, 2013, Kebebew, Ayele, 2010).

Table 10 showed that 83% of households were food secure because of *E. globulus* contribution to their income. Of the total households, 45.5% preferred to sale *E. globulus* in the case of emergency as compared to crops and livestock. The cash obtained from selling the *Eucalyptus* has filled the food shortage gaps of the families. *Eucalyptus* trees are regarded as insurance resource or life saviour, because they are cut and readily converted to cash during critical needs. The average annual income from *E. globulus* under poor, medium and rich households are 11219.27, 12207.48 and 15024.14 ETB/ha, respectively. In the study area,

T a b l e 9. Farm gate price of different crops at household level.

	Wealth categories			
	Poor	**Medium**	**Rich**	**Average**
Price of crops and inputs (ETB) Crops price				
Barley	739.84	729.08	732.76	733.89
Wheat	1,043.75	1,030.61	1,048.28	1,040.88
Peas	800	823.98	812.07	812.02
Beans	695.31	687.76	689.66	690.91
Teff	1,515.63	1,569.39	1,593.1	1,559.37
Cost of inputs per year	3,247.92	3,545.19	3,380.2	3391.1
Amount of crops sold to buy inputs [quintal(metric)]				
Barley	4.39	4.86	4.61	4.62
Wheat	3.11	3.44	3.22	3.26
Peas	4.06	4.3	4.16	4.17
Beans	4.67	5.15	4.9	4.91
Teff	2.14	2.26	2.12	2.17
Average	3.68	4	3.8	3.83

T a b l e 10. Household income contribution of *E. globulus*.

	Wealth categories					
	Poor	**Medium**	**Rich**	**Average**	**Total**	**%**
Rotation age (years)						
4 years	16	22	13		51	46.36
5 years	16	27	16		59	53.64
Rotation age (years) coppicing						
3 years	16	30	18		64	58.18
4 years	16	19	11		46	41.82
Average annual income from *E. globulus* (ETB)	11,219.2	12,207.48	15,024.14	12,816.96		
Income from *E. globulus* satisfy household food security						
Yes	20	43	28		91	82.7
No	12	6	1		19	17.3

E. globulus can start to provide income from the first and second rotation of 4 or 5 and 3 or 4 years, respectively, excluding in-between benefits. Kebebew and Ayele (2010) reported that *E. globulus* serves as a cash crop to smallholder farmers and contributed significantly to farmers livelihoods. Smallholder farmers harvest *E. globulus* starting from year 3 to 4 depending on the perceived products.

Conclusion

The results of the study showed higher soil bulk density, soil OC content and TN under *Eucalyptus* as compared to cultivated and degraded land, which implies less detrimental effect of *Eucalyptus* on soil fertility. The clay particles and CEC were significantly higher under the *E. globulus* compared with all land uses except forest. From livelihoods perspective, *E. globulus* plays an important role in addressing food security. The results also showed that 82.7% households were food secure from the income obtained from *E. globulus*. The average annual income from *E. globulus* under poor, medium and rich households are 11 219.27, 12 207.48 and 15 024.14 ETB/ha, respectively. If *E. globulus* can be restricted from the land use systems, the livelihoods of all households depending on the activity will be negatively affected. Therefore, the issue of discouraging *E. globulus* must take into account the current contribution of *E. globulus* to agricultural production.

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