

# The Socioeconomic impacts of Eucalypt Plantations on Rural Livelihood in Western Gurage Watersheds, Central-south Ethiopia

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## Research Article

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## **Abstract**

## **Background**

Rural landscapes, particularly those close to human settlements and main roads throughout the highlands of Ethiopia, appear greener than the outfields because of eucalypt plantations. The most common factors for eucalypt plantations are two: fuel and construction demands and to generate income.

## **Objective**

*This study tried to investigate the socioeconomic impacts of eucalypt plantations in Western Gurage Watersheds located in Central-south Ethiopia. The specific objectives are: to evaluate the socioeconomic importance of eucalypt plantations on the livelihood of farm households, and to assess perceptions on impacts of eucalypt plantation and coping strategies.*

## **Methods**

Systematic and purposive sampling method was employed by selecting households with eucalypt woodlots from the list of each Woreda's Kebeles. Close- and open-ended questionnaires were distributed to every fifth households that possessed eucalypt plantations. Three hundred eighty three questionnaires were distributed and collected from households found in three Woredas (districts) namely Cheha, Enemora Ener, and Eza located in the Watersheds. To supplement the information critical observations, discussions with focus groups and interviews with key informant were employed. The survey data were analyzed using both qualitative and quantitative techniques. To describe data acquired from critical observations, focus group discussions and key informant interviews; critical and logical qualitative data analysis technique were used. Descriptive and dispersive statistics such as frequency, percentage, mean, variance, standard deviation, p-value and correlation were employed using SPSS Version 20.

## **Results**

*The result showed that eucalypt plantation dominated fuel wood and construction consumption and substituted further encroachment to natural forests. From multiple responses given, households prefer planting eucalypts to indigenous trees because it is fast growing (100%), profitable (100%), needs lesser labor (100%), needs lower capital (100%), can be used for multipurpose (100%), and coppice itself fatly (93%). They rated income gained from eucalypt as 2nd next to enset.*

## **Conclusions**

Households may continue planting the species particularly for fuel wood and construction need since substituting it by other alternative seems not feasible and challenging. To sustain the livelihood and environment; appropriate management like site selection and substitutions by horticultural and cash crops using micro irrigation schemes for market needs are recommended. Conducting in-depth participatory research and specific policy ratification and promulgation on eucalypt plantations will sustain its utilization and curb the drawbacks.

### **1. Introduction**

In Ethiopia, farmers continued planting eucalypts because it is used as source of income apart from its perceived undesirable effect on soil and water (Chanie et al., 2013). Eucalypt species provide a variety of socio-economic benefits. Eucalypts provide fuel wood, charcoal, construction timber, poles, paper pulp, and nectar for honey production, eucalypts oil, medicine, shade, job and scenic value around compounds. Due to its fast growth, the foremost benefit of eucalypt species is its fuel wood use (Jagger and Pender, 2000; Teketay, 2000).

Beside the above, planting eucalypt is less costly than other growing agricultural crops in Ethiopia. The labor cost is only at planting, thinning and harvesting period which is once every three to nine years. Generally, social and environment services can be changed to better position in such a way that livelihoods and natural forests improved through plantation (Bukenya et al., 2009; Ketsela, 2012). Having eucalypt woodlots can also reduce women and children fuel wood collection time and energy and indirectly allows children to invest their time on their education (Zerga, 2016).

Eucalypt species can supply wood in good quantities within 4–5 years from comparatively small areas of land (Teketay, 2000). Eucalypt has been found to be useful in honey production and thus has been recorded in the honeybee flora of Ethiopia (Fichtl and Adi, 1994).

In some communities, eucalypt trees are regarded as a living bank account or insurance resource or life savior, since they can be cut and readily converted to cash during critical needs (Teketay, 2000; Negash, 2002; Negussie, 2004). In other communities, such as in the Gurage Zone, planting eucalypt is a privilege and obligation of all households not only for meeting household wood requirements and generate cash revenues but to preserve social pride and reputation (Negussie, 2004; Zerga, 2016). Today in many places, own grown eucalypt wood covers most of the construction wood needs of households and constitutes a substantial part of fuel wood consumptions (Bewket, 2003; Negussie, 2004; Mekonnen et al., 2007; Zerga and Woldetsadik, 2016). For instance, 45% of interviewed households in Chemoga watershed in Gojam estimated that between 75 and 100% of their demand for fuel wood is met by privately planted trees; while a further 20% indicated that these trees meet 50–75% of their fuel wood needs (Bewket, 2003).

In Gurage highlands wood demand for construction of the wood-extensive traditional tukuls, and the scarcity of wood sources from natural sources for such construction makes planting of eucalypt quite imperative (Negussie 2004, Zerga, 2016). In Arsi highlands of central Ethiopia, eucalypt wood grown by farmers supply 86% of firewood, 31% of charcoal, 100 % of leaves and twigs for firewood and 100% of poles used by urban dwellers. In rural areas the wood from eucalypt contributes to 92% of poles, 74% of timber, 85% of firewood, 40% of charcoal, 83% of posts and 91% of farm implements. (Mekonnen et al. 2007).

Farmers also grow eucalypt for income generation. In areas, such as northern, central, and southern highlands of Ethiopia where natural forests have been impoverished eucalypt farming is contributing up to 25 % of household cash income (Teklay, 1996; Teshome, 2004; Mekonnen et al., 2007). In general, the above findings indicate that eucalypt has the potential to raise farm incomes, reduce poverty, increase food security, and diversify smallholder farming systems.

Especially, eucalypt can substitute industries' demand for wood product such as lumber, plywood, veneer, poles and pulp (Bekele, 2011; Desalegn and Tadesse, 2010). This study tried to investigate the socioeconomic impacts of eucalypt plantations in Western Gurage Watersheds. The specific objectives were to evaluate the socioeconomic importance of eucalypt plantations on the livelihood of farm households, and to assess perceptions of communities on impacts of eucalypt plantation and coping strategies.

## 2. Research Methods

### 2.1. Study area

The Gurage Zone is located in Central-south Ethiopia with the location between  $7^{\circ}40'$  to  $8^{\circ}30'$  North latitude and  $37^{\circ}30'$  to  $38^{\circ}40'$  East longitude and covers an area of 5,932 km<sup>2</sup>. The Zone is bounded with Oromia Region in the west, north and east, Yem Special Woreda in the southwest, Hadiya Zone in the south and Silte Zone in the east. Topographically, the Gurage Zone lies within an elevation, ranging from 1,000 to 3,638 m. The highest point in the Zone is Mt. Zebidar. The climate of Gurage Zone is affected by altitudinal gradients. The four traditional agro-ecological zones (AEZs), namely *wuruch*, *dega*, *woina dega* and *kolla* are found in the Zone. However, *woina dega* is the dominant one. The average temperature ranges from < 3°C in the Gurage mountain chains to 28°C in the Gibe Gorge. The annual range of rainfall falls between 600 and 1,900mm. These ranges of agro-ecology have enabled the Zone to grow different types of crops, such as *enset* (*Ensete ventricosum* (Welw.) Cheeseman) (hereafter referred to as *Enset*), cereals, pulses, oil seeds, vegetables and fruits as well as support livestock, sheep, goat and pack animals. Different wild animals and birds inhabit the Zone, owing to this climatic diversity.

As noted by Woldetsadik (1994), soil colors in the *enset* growing areas, like Gurage Zone, range from brown and black to red. Two of the soil groups, Pellic Vertisols and Euric Nitsols, are most common and cover more than 60% of the region. Depending upon the population pressure and local farming systems, Vertisols are intensively cultivated and mostly devoted to grain production in the *dega* (upland). However, they are left largely for grazing in the low plateaus, the lower *woina dega* (midland) and the upper *kolla* (lowland) sections of the region.

Based on the 2007 census conducted by the Central Statistical Agency (CSA) of Ethiopia, the Zone had a total population of 1,279,646 ( $1279646 \times 0.5 = 1919469$ ) of whom 49% are males and 51% are females. The Zone has a population density of greater than 450 person km<sup>-2</sup>. About 9.36% of them are urban inhabitants and the remaining are rural dwellers. Gurage Zone is one of the most densely populated areas in Ethiopia. High population pressure and a long history of settlement have resulted in an increasing quest for agricultural land, wood for farmhouse construction, fuel and other uses. This, in turn, has resulted in the degradation of the natural forests and shrubs along river valleys (Woldetsadik, 2003).

Gurage Zone is divided by four drainage basins, namely Awash, Rift Valley, Blate and Omo-Gibe (Sahle et al., 2018). With the exception of minor deviations at local level, the streams in the Zone have a dendrite drainage pattern. The Western Gurage Watersheds drain to Omo-Gibe Basin and covers large areas. In the western parts of Gurage, several rivers and streams are available, which drains from East to West to Gibe River. The major rivers are Wabe, Winike, Megecha, Rebu, Zizat, Gogare and Dire. These rivers have several numbers of streams, which emerge from the Gurage Mountains and join at different locations. The rivers Winike, Gogare and Derie are the main rivers next to Wabe River, and together cover an area of 173,476 ha (Fig. 2.1).

From these, the main watershed is Winike, which includes Megecha and Zizat rivers and covers an area of 117,030 ha. The Gogare and Drie watersheds cover an area of 30,739 and 25,707 ha, respectively. These watersheds were selected due to their dense population and high coverage of eucalypts under expansion.

### 2.2. Secondary Data

To get clear understanding of the concept such as eucalypts' expansion, eucalypts' competition, income diversification, livelihood support and the like, secondary data from journals, theses, and reports were reviewed critically. In this part exclusion and inclusion approach, selecting and retrieving the appropriate and recent literatures were made. Thereafter the final report (findings) was analyzed and synthesized to show and fill the research gap.

### 2.3. Primary data

#### 2.3.1. Sampling method, procedure and distribution

For the purpose of the study, samples from three Woredas located within Western Watersheds of Gurage Zone were collected. The selected Woredas were Cheha, Enemorna Ener, and Eza. These Woredas were purposefully selected due to large coverage of the watersheds, dramatic expansion of eucalypts farming and thereby high eucalypts pole production

To get primary data about the study, systematic and purposive sampling method was employed. Thus, after selecting households with eucalypt woodlots from the list of each Woreda's *Kebeles*, close- and open- ended questionnaires were distributed to every 5th households possessing eucalypt plantations. The

main reason for selecting this sampling method is to avoid the inclusion of non-eucalypt tree farmers and to keep the validity of the representative samples (to cover large villages within the *Kebeles*).

### 2.3.2. Sample size determination

From the total 71,792 household population living in the three woredas (CSA, 2007), 383 household respondents were selected (Table 2.1) using the following formula by assuming confidence level at 95% and margin of error) at 5%. The sampling formula is shown as follow (Cothari, 2004).

Table 2.1  
Sample size and sampling distribution.

No.	Woredas	Sample <i>kebeles</i> based on agroclimate	Total No. of Households	No. of sample Households			%
1	Cheha	Moche, Wodro and Azerna Sise	27,527	143	D	W	K
				47	49	47	37
2	Enemorna Ener	Agata, Terede and Gonche Bete	25,315	140	45	47	48
3	Eza	Worit, Shebraden and Zigba Boto	18,950	100	33	34	33
Total	3	9	71,792	383	125	130	128
D = Dega; W = Woina dega; K = Kolla							
Source: Compiled from CSA, 2007							

$$n = Z^2(p)(q)/d^2$$

Where, p = sample proportion of successes or 0.5;

q = Probability of failure ( $1 - p$  or  $1 - 0.5 = 0.5$ );

d = margin of error and it is 5% (0.05)

n = number of trials (size of the sample);

z = standard variate for given confidence level (as per normal curve area table) and it is 1.96 for a 95%.

Therefore:  $n = 1.96^2(0.5)(0.5)/0.0025$

$$n = 1.96^2 * 0.25 / 0.0025$$

$$n = 384$$

$$\text{Therefore: } S = N-n/N-1(n) = 71792-384/71792-1*384$$

$$S = 383$$

Where, N = number of household in the woredas

S = sample size

The numbers of households asked were 143, 140, and 100 in Cheha, Enemorna Ener, and Eza Woredas respectively. These sample sizes were selected based on the extent of expansion. The selected *Kebeles* in each district represented *Kolla* (Lowland), *Woina Dega* (Midland) and *Dega* (Upland) traditional climatic zones. Thus 47, 49 and 47 households in Moche, Wodro and Azerna Sise *Kebeles* respectively were selected from Cheha Woreda; 45, 47 and 48 households in Agata, Terede and Gonche Bete *Kebeles* respectively were selected from Enemorna Ener Woredas; and 33, 34 and 33 households in Worit, Shebraden and Zigba Boto *Kebeles* respectively were selected from Eza Woreda. Tabular data analyses employed are based on the Woreda pooled results to reduce burdened numerical information of the nine *Kebeles*.

To supplement the information, critical observations, discussions with focus groups and key informant interviews were employed. Each group included six up to eight members. Key informant interviews were conducted with well experienced individuals.

### 2.3.3. Method of Data Analysis

The survey data were analyzed using both qualitative and quantitative techniques. To describe data acquired from observations, focus group discussions, key informants' interviews, critical and logical qualitative data analysis techniques were used. Data acquired from questionnaires were analyzed and summarized in a form of tables and graphs using Statistical Package for Social Sciences (SPSS) version 20. Descriptive and dispersive statistics such as frequency, percentage, mean, variance, standard deviation, p-value and correlation were employed.

## 3. Results

### 3.1. Demographic and socioeconomic characteristics of the households

From the total sample households, 79% and 21% of them are males and females respectively. The majorities (78%) of the respondents were married. The remaining 21% and 1% of the respondents were widowed and separated respectively. With regards to educational qualification, a high proportion of the respondents (67%) were literate. Among this 59% of them can read and write and 7% and 1% of the respondents completed elementary and junior education. Illiterate respondents constituted 33%. As to the religion composition of the households, about 59% and 37% of the respondents are Orthodox and Muslims. The remaining 3% and 1% are Protestants and Catholics.

The result shows that (Table 3.1) about 52% and 48% of the households have land holdings of 0.2 to 0.5 and 0.5 to 1 hectare respectively. The mean value of land holding size per household is 0.56 hectare. Hence the land holding size is extremely diminutive. Concerning livestock production, most of the respondents engaged in rearing of cattle (48%) and followed by sheep (19%) and goat (19%). These three types of livestock collectively constitute about 86% of the whole livestock rearing. The rest collectively constitute 14%. From the multiple responses; major source of exchange incomes include: sale of eucalypt poles (100%), remittance from urban areas (100%), sale of cereal crops (barely, wheat, pees) (81%), sale of fruits, vegetables, coffee and Chat (71%), sale of livestock (61%), and sale of *enset* and its byproducts (39%).

Table 3.1  
Socioeconomic characteristics of the households.

Categories	Alternatives	Frequency	%	Mean	Variance	Std. dev.
Land Holding size (ha)	0.2-0.5h	185	48	0.56	0.04	0.2
	0.5-1h	198	52			
Number of livestock	Cattle	1854	48	521.5	406960.25	637.94
	Horse	208	5			
	Donkey	265	7			
	Mule	63	2			
	Sheep	720	19			
	Goat	19	19			
Activities other than farming	Petty trade	73	19	89.11	12524	111.92
	Part-time trade in urban areas	142	37			
	Weaving	47	12			
	Pottery	0	0			
	Carpentry	32	8			
	Blacksmith	2	0.5			
	Handcraft	37	10			
	Seasonal Migration	86	22			
	Wage labor	383	100			
Major source of income	Sale of cereal crops (barely, wheat, pees)	313	82	288.7	6925.56	83.22
	Sale of eucalypt poles	383	100			
	Sale of fruits, vegetables, coffee and Chat	272	71			
	Sale of livestock	233	61			
	Sale of <i>enset</i> and its by products	148	39			
	Remittance from urban areas	383	100			

Source: Field Survey (2017).

## 3.2. Socioeconomic importance of eucalypt plantations on the livelihood

### 3.2.1. Amount and location of eucalypt tree planted by households

Households planted many number of eucalypt trees as a result of its benefits much better than other tree species particularly for fuel wood and construction needs. Most of the households planted eucalypts on sloppy areas (61%) compared to flat areas (39%) from 2001 to 2017 periods. In average about 22.6 % of the households planted less than 500 eucalypt trees. Collectively about 77.4% of them planted greater than 500 eucalypt trees (Table 3.2).

Table 3.2. Number of eucalypt trees planted in the past 20 years.

Years planted	Number of trees planted						Location of trees			
	<500	%	500-1000	%	>1000	%	Flat	%	Sloppy	%
2013-2017	73	19	100	26	210	55	165	43	218	57
2009-2013	96	25	175	46	112	29	146	38	237	62
2005-2009	88	23	120	31	175	46	130	34	253	66
2001-2005	93	24	130	34	160	42	125	33	258	67
>2001	84	22	167	44	132	34	179	47	204	53
Mean	86.8	22.6	138.4	36.2	157.8	41.2	149	39	234	61
Variance	80.7		1010		1447		525.5		525.5	
Std. dev.	8.983		31.79		38.04		22.92		22.92	

Source: Field Survey (2017).

### 3.2.2. Purpose of plantations and average eucalypt poles sold

From multiple responses given (Table 3.3); households' purpose of planting eucalypts tree include for firewood (100%), construction including fencing (100%), sale (100%), soil and water conservation (80%) and farm tools (89%). As described in Table 3.4, 63% of the households sell 100 to 500 eucalypt poles per four years; about 10% and 21% of them sell 500 to 1000 and less than 100 poles respectively. Households who sell 4000 to 7000 poles are only 6%. This shows that 79% of the households sell greater than 100 poles per four years period.

Table 3.3  
Multiple responses on for what purpose do households plant eucalypt trees.

Alternative	Cheha	%	En/Ener	%	Eza	%	Total	%
Firewood	143	100	140	100	100	100	383	100
Construction including fencing	143	100	140	100	100	100	383	100
Sale	143	100	140	100	100	100	383	100
Soil and water conservation	117	82	116	83	72	72	305	80
Farm tools	127	89	128	91	85	85	340	89
Mean	134.6	92.2	132.8	94.8	91.4	91.4	358.8	93.8
Variance	115.84	55.36	92.16	46.96	127.84	127.84	1000.96	65.78
Std. dev.	10.76	7.44	9.6	6.85	11.31	11.31	31.64	8.11

Source: Field Survey (2017).

Table 3.4  
Average eucalypt poles sold to market per four year.

Number of poles sold	Cheha	%	En/Ener	%	Eza	%	Total	%
< 100	31	22	31	22	19	19	81	21
500 – 100	90	63	93	67	58	58	241	63
1,000-500	14	10	9	6	15	15	38	10
4,000- 1000	8	5	7	5	8	8	23	6
7,000–4,000	0	0	0	0	0	0	0	0
7,000–10,000	0	0	0	0	0	0	0	0
>10,000	0	0	0	0	0	0	0	0
Mean	20.43	14.29	20	14.29	14.29	14.29	54.71	14.29
Variance	914.24	449.91	991.43	515.06	369.35	369.35	6522.78	445.35
Std. dev.	30.24	21.21	31.49	22.69	19.23	19.23	80.76	21.1

Source: Field Survey (2017).

### 3.2.3. Preference of planting eucalypts to indigenous trees

From multiple responses given (Table 3.5), households preferred planting eucalypts to indigenous trees because: it is fast growing (100%), good for fuel wood and construction (100%), profitable, needs lesser labor (100%), needs lower capital (100%), can be used for multipurpose (100%), coppice itself faster than other species (100%) and more market demand) (93%).

Table 3.5  
Multiple responses on households' preference of planting eucalypts to indigenous trees.

Alternative	Cheha	%	En/Ener	%	Eza	%	Total	%
Fast growing	143	100	140	100	100	100	383	100
Good for fuel wood and construction	143	100	140	100	100	100	383	100
Profitable (has lucrative profit, more market demand)	136	95	133	95	89	89	358	93
Needs lesser labor	143	100	140	100	100	100	383	100
Needs lower capital	143	100	140	100	100	100	383	100
Can be used for multipurpose	143	100	140	100	100	100	383	100
Coppice itself faster than other tree species	143	100	140	100	100	100	383	100
<b>Mean</b>	<b>142</b>	<b>99.29</b>	<b>139</b>	<b>99.28</b>	<b>98.43</b>	<b>98.43</b>	<b>379.37</b>	<b>99</b>
<b>Variance</b>	<b>6</b>	<b>3.06</b>	<b>6</b>	<b>3.06</b>	<b>14.82</b>	<b>14.82</b>	<b>66.98</b>	<b>6</b>
<b>Std. dev.</b>	<b>2.45</b>	<b>1.75</b>	<b>2.45</b>	<b>1.75</b>	<b>3.85</b>	<b>3.85</b>	<b>8.18</b>	<b>2.45</b>

Source: Field Survey (2017).

### 3.2.4. Income earned from different sources

From various sources of income in 10 to 15 years (from 2009 to 2013), households who accounted 8% and 92% earned 10000 ETB (Ethiopian Birr) or USD 150.15–300.3 (USD 1 = 33.3 at current currency exchange rate) and > 10000 ETB from sell of eucalypts; 42% and 58% earned 5000–10000 ETB and > 10000 ETB from sale of food crops; 39% and 61% earned 5000–10000 ETB and > 10000 ETB from non-farm works; and 50% and 50% earned < 5000 ETB and > 5000 ETB from other sources respectively. From 2013 to 2017 income from the same sources households who accounted 12 % and 88% earned 5000–10000 ETB and > 10000 ETB; 54% and 46% earned 5000–10000 ETB and > 10000 ETB; 33% and 36% earned 5000–10000 ETB and > 10000 ETB; and 67% and 64% earned < 5000 ETB and > 5000 ETB respectively (Table 3.6).

Table 3.6  
Income earned from different sources in the 10–15 years (in ETB).

Years	From sale of eucalypts		From sale of food crops		From non-farm works		From other sources		Mean	Var.	Std. dev.
	5000–10000	> 10000	5000–10000	> 10000	5000–10000	> 10000	< 5000	> 5000			
2009–2013	31	352	160	223	150	233	191	192	187.7	7930	89.1
2013–2017	45	338	205	178	128	255	139	244			

Source: Field Survey (2017).

In the successive four years of 2014, 2015, 2016, and 2017 greater than 10000 ETB generated from the sale of eucalypts by respondents accounted 56%, 60%, 61%, and 69% respectively. In the same successive years 44%, 40%, 39% and 31% of the households accounted less than 10000 ETB respectively (Table 3.7).

Table 3.7  
Cash generated in ETB from the sale of eucalypt tree products during the last four years.

Years sold	Cash generated in ETB												%			
	< 10000						> 10000									
	Cheha	%	En/Ener	%	Eza	%	Total	%	Cheha	%	En/Ener	%	Eza	%	Total	%
2017	45	31	47	34	28	28	120	31	98	69	93	66	72	72	263	6
2016	55	38	53	38	40	40	148	39	88	63	87	62	60	60	235	6
2015	61	43	60	43	32	32	153	40	82	57	80	57	68	68	230	6
2014	67	47	68	48	35	35	170	44	76	53	72	51	65	65	213	5
Mean	57	39.75	57	40.75	33.75	33.75	147.7	38.4	86	60.5	83	59	66,25	66,25	235.25	1
Variance	52.8	35.69	61.5	27.69	19,19	19,19	323.19	22.18	66	36.75	61.5	31.5	19.19	19.19	323.19	1
Std. dev.	7.27	5.97	7.84	5,26	4.38	4.38	17.98	4.72	8.12	6.06	7.84	5.61	4.38	4.38	17.98	1

Source: Field Survey (2017).

### 3.2.5. Major objectives of economic activities improving income first

From multiple responses of major objectives of households' economic activities (Table 3.8); crop cultivation accounted 100% for food and 100% for income; animal rearing accounted 100% for food and 70% for income; eucalypt tree farming accounted 100% for income; petty-trade accounted 100% for income;

handicrafts accounted 100% for income; off farm wage employment accounted 20% for food and 100% for income; remittance money accounted 100% for income; and selling grass for animal fodder accounted 11% for income.

Table 3.8  
Multiple responses on major objectives of households' economic activities.

Alternatives	Objective												
	Food						Income						
	Cheha	%	En/Ener	%	Eza	%	Total	%	Cheha	%	En/Ener	%	Eza
Crop cultivation	143	100	140	100	100	100	383	100	143	100	140	100	100
Animal rearing	143	100	140	100	100	100	383	100	95	66	87	62	85
Eucalypt tree farming	0	0	0	0	0	0	0	0	143	100	140	100	100
Petty-Trade	0	0	0	0	0	0	0	0	143	100	140	100	100
Handicrafts	0	0	0	0	0	0	0	0	143	100	140	100	100
Off farm wage employment	30	21	28	20	20	20	78	20	143	100	140	100	100
Remittance money	0	0	0	0	0	0	0	0	143	100	140	100	100
Selling grass for animal fodder	0	0	0	0	0	0	0	0	18	13	16	11	10
Mean	39.5	27.63	38.5	27.5	27.5	27.5	105.5	27.5	121	84.88	118	84.13	87
Variance	3664.5	1791.98	3515.75	1793.75	1783.75	1783.75	26302.5	1793.75	1773.48	861.86	1783.61	918.61	771.
Std. dev.	60.53	42.33	59.29	42.35	42.35	42.35	162.18	42.35	42.11	29.36	42.23	30.31	27.7

Source: Field Survey (2017).

About 39%, 30.8%, 14%, 8%, 3.9%, 2%, 1%, 0.8%, and 0.5% of households improve their income by planting more number of *enset*, planting more eucalypts, cultivating crops, planting *chat*, raising more livestock, engaging more in non-and off-farm activities (part time works), planting more coffee trees, planting fruit trees (orchard) and seasonal labor migration respectively (Table 3.9).

Table 3.9  
Activities that improve households' income first.

Alternative	Cheha	%	En/Ener	%	Eza	%	Total	%
Planting more number of <i>enset</i>	58	41	55	39	37	37	150	39
Planting more bahirzaf (eucalypts)	40	28	43	31	35	35	118	30.8
Planting <i>chat</i>	12	8	10	7	7	7	29	8
Planting fruit trees (orchard)	1	0.7	1	0.7	1	1	3	0.8
Cultivating crops	20	14	20	14	13	13	53	13.8
Raising more livestock	6	4	5	4	4	4	15	4
Engaging more in non-and off-farm activities	3	2	3	2	2	2	8	2
Planting more coffee trees	2	1.4	2	1.4	1	1	5	1
Seasonal labor migration	1	0.7	1	0.7	0	0	2	0.5
Mean	15.89	11.09	15.6	11.09	11.11	11.11	42.55	11.11
Variance	365.21	182.36	359.58	182.59	191.43	191.43	2678.02	181.89
Std. dev.	19.11	13.50	18.96	13.51	13.84	13.84	51.74	13.45

Source: Field Survey (2017).

### 3.2.6. Long-term strategies to tackle the food shortage problems

From multiple responses (Table 3.10), the short- and long-term strategies to tackle the food shortage problems of the households include planting more eucalypt trees (90%), producing more crops (74%), planting cash crops (*Chat*, coffee, fruits) (62%), using irrigation farms (30%) and working on offfarm

activities (17%).

Table 3.10  
Multiple responses on short- and long-term strategies to tackle the food shortage problems.

Strategies	Cheha	%	En/Ener	%	Eza	%	Total	%
Producing more crops	101	71	103	74	79	79	283	74
Planting more eucalypt trees	123	86	125	89	100	100	345	90
Working on offfarm activities	23	16	25	18	14	14	62	17
Using irrigation farms	40	28	42	30	32	32	114	30
Planting cash crops ( <i>chat</i> , coffee, fruits and vegetables)	90	63	80	57	68	68	238	62
<b>Mean</b>	<b>75.4</b>	<b>52.8</b>	<b>75</b>	<b>53.6</b>	<b>58.6</b>	<b>58.6</b>	<b>208.4</b>	<b>54.6</b>
<b>Variance</b>	<b>1426.64</b>	<b>701.36</b>	<b>1379.6</b>	<b>701.04</b>	<b>983.04</b>	<b>983.04</b>	<b>11089.04</b>	<b>740.64</b>
<b>Std. dev.</b>	<b>37.78</b>	<b>26.48</b>	<b>37.14</b>	<b>26.48</b>	<b>31.35</b>	<b>31.35</b>	<b>105.31</b>	<b>27.21</b>

Source: Field Survey (2017).

## 4. Discussion

### 4.1. Demographic and socioeconomic characteristics of the households

The results of the study indicated that the male household proportion is large and this situation may contribute for the expansion of eucalypts. This could be the fact that eucalypts planting is practiced more by males than females. Females engaged mainly in horticultural activities. The mean age of the respondents was about 59 years. This is adulthood age. The P-Value is < 0.00001. It is significant at  $p < 0.05$ . Therefore many of them seem have enough understanding about the aspects of eucalypts in their localities. The age is also an ideal for a long lasting exposure in land use practice. More than three quarter of the households were married. This agrees with the findings of Soyebo et al (2005) that agriculture is very much practiced by married people to sustain the livelihood of family.

A high proportion of the households (two-third) were literate. Hence most of them can read and write. The mean and standard deviation values are 54.71 and 81.58 respectively. The P-Value is < 0.000029. It is significant at  $p < 0.05$ . Since adequate education enhances farmers' level of management practices, it is therefore expected that about one-third of the households would be prone to unsustainable land use management.

The result also shows that the mean value of land holding size per household is 0.56. However, nearly half of them have land holdings less than 0.5 hectare and hence the land holding size is extremely diminutive. The P-Value is < 0.00001. It is significant at  $p < 0.05$ . Thus, most of them are small-scale farmers. Moreover the land is fragmented (broken up) in to a number of small separate plots, often located at distant from each other. Hence, this situation adversely affected agricultural performance and land management because travel to and from home consumes longer time and labor energy. In other scenario the expansion of eucalypt resulted in further shrinkage of the land possession.

As to the religion composition of the households, the majorities of the households are Orthodox and followed by Muslims, Protestants and Catholics. This indicates that in addition to fuel wood consumption, construction and market use; collectively all (100%) of the respondents consume huge amount of eucalypts products for fuel wood and other purpose during yearly celebrations of "Meskel" and "Arafah"

From the multiple responses given major source of exchange incomes come mainly from sale of eucalypt poles, and followed by remittance from urban areas, sale of cereal crops (barely, wheat, pees), sale of fruits, vegetables, coffee and *chat*, sale of livestock, and sale of *enset* and its byproducts (Table 3.1). From multiple responses given; offfarm activities practiced by the households, wage labor is practiced by all and followed by part-time trade in urban areas, seasonal migration, petty trade, weaving, handcraft, carpentry, and blacksmith (Table 3.1). The mean and standard deviation values are 89.11 and 111.92 respectively. The P-Value is < 0.004322. It is significant at  $p < 0.05$ . All these activities support households' livelihood in addition to farm activities.

### 4.2. Socioeconomic importance of eucalypts for rural livelihood

#### 4.2.1. Amount and location of eucalypt tree planted by households

Most of the households planted eucalypts on sloppy areas (61%) compared to flat areas (39%) from 2001 to 2017 periods (Table 3.2). The mean values are 234 and 149 for sloppy and flat areas respectively. The standard deviation values of trees planted in flat and sloppy areas are 22.92 and 22.92 respectively. The P-Values is < 0.00001 for each. Hence, the results are significant at  $p < 0.05$  for both flat and sloppy area plantings. The value of R is -1. This is a strong negative correlation, which means that high X variable scores go with low Y variable scores (and vice versa). Hence households are shifting from flat areas to sloppy areas. Farmers shift to flat areas when there is crop production failure in flat areas, for transport accessibility and tenure security.

Collectively about 77.4% of them planted greater than 500 eucalypt trees. From this, 41.2% of them planted greater than 1000 trees (Table 3.4). This shows that the species is well adopted and practiced by the households. The mean values of households that planted less than 500, 500 to 1000 and greater than 1000 eucalypts trees from 2001 to 2017 were 86.8, 138.4 and 154.8 respectively. The standard deviation values of the same planted trees in these years were

8.99, 31.79 and 38.04 respectively. The P-Value is < 0.00001 for each. Hence the results are significant at  $p < 0.05$  for all eucalypt planted. This indicates that households' engagement in planting the species at such amounts is attributable to its multipurpose value.

## 4.2.2. Purpose of plantations and average eucalypt poles sold

From multiple responses given; households' purpose of planting eucalypts are mainly for firewood (100%), construction including fencing (100%), sale (100%), soil and water conservation (80%) and farm tools (89%) (Table 3.3). The total mean and standard deviation values are 358.8 and 31.64 respectively. The P-Value is 0.000024. It is significant at  $p < 0.05$ . This indicates that all the mentioned purposes are almost equally important for households. In line with this as reported by Zerga and Berta (2016) about 95% households use eucalypts for fire wood, construction, source of income and farm tools. Similarly as reported by Negussie (2004), the inherent growth quality of eucalypts made their poles quite ideal inverted V shapes. Sturdy and long poles (12 to 15 m) with reasonable flexibility and lightweight are preferred candidates. No other substitute has so far been employed as roof supporters, straight and sturdy eucalypt poles of about 5–7 meters long provide a stalwart support to the upper part of the roof by stepping on the 'waist' and 'shoulder' of the main pillar. Hence there is indispensable attachment of the species to households' needs (See Fig. 3.1).

About 63% of the households sell 100 to 500 eucalypt poles per four years; about 10% and 21% of them sell 500 to 1000 and less than 100 poles respectively (Table 3.4). Households who sell 4000 to 7000 poles are only 6%. This shows that 79% of the households sell more than 100 poles per four years period. The mean value is 224.5 and the standard deviation is about 130.4. The P-Value is < 0.00001. It is significant at  $p < 0.05$ . As reported by key informants and focus group discussants, some households sell more than 80,000 ETB = USD 2402.4.

## 4.2.3. Preference of planting eucalypts to indigenous trees

From multiple responses given, households preferred planting eucalypts to indigenous trees because: it is fast growing (100%), good for fuel wood and construction (100%), profitable (has lucrative profit, needs lesser labor (100%), needs lower capital (100%), can be used for multipurpose (100%), coppice itself faster than other tree species (100%) and more market demand) (93%) (Table 3.5). The mean value is 379.37 and the standard deviation value is 8.18. The P-Value is < 0.00001. It is significant at  $p < 0.05$ . This indicates that households' preference in planting eucalypt species than others is quite justifiable. Eucalypt is used for construction at various stages (3 to 4 years- small poles, 5 to 6 years- medium poles, 7 to 8 years- big poles and greater than 9 years- logs). Due to its role in fuel wood and construction partly households planted the species in continuously as the first farm forestry practice. As reported by Zerga and Berta (2016), eucalypt trees are an important livelihood support at household level and appear irreplaceable by other trees.

With the same scenario, van Noordwijk (2019) reported that trees are assets that can be cut and sold for cash or exchanged for goods in times of need. In the Maradi and Zinder Regions of Niger, and where 1.2 million households now sustain medium-to-high densities of tree populations on their farms, tree branches are cut on a continuous cycle for household fuel wood supplies and for sale. In the same vein Mekonnen (2010) stated that farmers suggested what trees they want, and have eucalypt trees within their farming systems.

## 4.2.4. Income earned from different sources

From various sources of income in 10 to 15 years (from 2009 to 2013), households who accounted 8% and 92% earned 5000–10000 ETB or USD 150.15–300.3 and > 10000 ETB from sell of eucalypts and followed by from sale of food crops, from non-farm works, and from other sources (Table 3.6). From 2013 to 2017 income from the same sources, households who accounted 12 % and 88% earned 5000–10000 ETB and > 10000 ETB from sell of eucalypts and followed by from sale of food crops, from non-farm works, and from other sources. The mean value of respondents is 187.7 and the standard deviation is 89.1. The P-Value is 0.014193. It is significant at  $p < 0.05$ . When we compare all income sources, income gained from the sale of eucalypts is much dominant than others. The study by Kebebew and Ayele (2010) also confirmed that income from eucalypt sale constituted the largest share compared with teff, wheat and barley and its contribution to household financial income was 50%.

In the successive four years of 2014, 2015, 2016, and 2017, greater than 10000 ETB generated from the sale of eucalypts by respondents accounted 56%, 60%, 61%, and 69% respectively. In the same successive years, 44%, 40%, 39% and 31% of the households accounted less than 10000 ETB respectively (Table 3.7). The mean value who generated less than 10000 ETB is 147.75 and the standard deviation is 17.98. The P-Value is < 0.00001. It is significant at  $p < 0.05$ . The mean value who generated greater than 10000 ETB is 235.25 and the standard deviation is 17.98. The P-Value is < 0.00001. It is significant at  $p < 0.05$ . The R value is 0.3131 and it is a positive correlation. This indicates that the trend of income generation is decreased for those generated less than 1000 ETB and increased for those generated greater than 1000 ETB from 2014 to 2017. Mekonnen et al (2007) also confirmed that eucalypts contributed 92 %, 74 %, 85 %, 40 %, 83 % and 91 % of construction poles, timber, firewood, charcoal, posts and farm implements wood sources for rural livelihoods.

## 4.2.5. Major objectives of economic activities improving income first

From multiple responses of major objectives of households' economic activities; crop cultivation accounted 100% for food and 100% for income; animal rearing accounted 100% for food and 70% for income; eucalypt tree farming accounted 100% for income; petty-trade accounted 100% for income; handicrafts accounted 100% for income; off farm wage employment accounted 20% for food and 100% for income; remittance money accounted 100% for income; and selling grass for animal fodder accounted 11% for income (Table 3.8). The mean value for food purpose is 105.5 and the standard deviation is 173.4. The P-Value is 0.043541. It is significant at  $p < 0.05$ . The mean value for income purpose is 173.4 and the standard deviation is 121. The P-Value is < 0.00001. It is significant at  $p < 0.05$ . The value of R is 0.0243. Hence it is a positive correlation. From the figures stated one can understand that crop cultivation and animal rearing are directly used for food supply and they are also marketable and used for generating household income. Others are practiced primarily for household income generation purpose. However, households' incomes generated from eucalypts and other activities can be used for purchasing food stuffs and sustain food security and thereby rural livelihoods.

Households improve their income mainly by planting more number of *enset* (39%) and planting eucalypts (30.8%), and followed by cultivating crops, planting *chat*, raising more livestock, engaging more in non-and off-farm activities, planting more coffee trees, planting fruit trees and seasonal labor migration

respectively (Table 3.9). The mean value is 42.55 and the standard deviation is 51.74. The P-Value is < 0.00001. It is significant at p < 0.05. From these figures we can understand that the role of *enset* and eucalypt collectively is nearly 70%. They rated income gained from these two as 1st and 2nd respectively.

## 4.2.6. Long-term strategies to tackle the food shortage problems

From multiple responses, the short- and long-term strategies to tackle the food shortage problems of the households include planting more eucalypt trees (90%), producing more crops (74%), planting cash crops (*chat*, coffee, fruits) (62%), using irrigation farms (30%) and working on offfarm activities (17%) (Table 3.10). The mean value is 208.4 and the standard deviation is 117. The P-Value is < 0.00001. It is significant at p < 0.05. The role played by eucalypt plantations in mitigating such shortcomings seems much better than other activities.

The recent study by Ayele and Teketay (2020), also confirmed that planting and managing plantation forests by local people may help to improve and diversify their incomes, suggesting that local communities may have higher dependencies on plantation forests to meet their livelihoods.

## 4. Conclusion And Recommendations

Households in the study area plant eucalypt as a primary farm forestry practice partly for firewood and construction needs. Its contribution in fulfilling financial demand is sustainable and appears much better than other agricultural engagements. There is indispensable attachment between the purposes and household needs particularly in firewood, construction. Hence substituting it for firewood and construction by other in the near future seems very challenging. The recent progresses of hydro electrification establishments in the country may not substitute rural fuel wood needs at full-fledged status in the near future. Other superiority is as a result of its attractive price value due to the booming construction industry and other manufacturing needs in urban areas of the country.

The young farmers plant 1000 to 5000 eucalypt seedlings on lands previously covered by crops. As reported by focus groups the young generations resist advice from elders. In average about 22.6%, 36.2% and 41.2% of the households planted less than 500, 500 to 1000 and greater than 1000 eucalypt trees respectively. About 77.4% of the respondents planted greater than 500 eucalypt trees.

As reported by focus groups and key informants, some farmers started counting more than 100,000 ETB (USD 3003) from the sale of eucalypt products that was not happened ever in history. Farmers started generating greater than 5,000 to 10,000 ETB (USD 150.15 to 300.3) many times and 25,000 to 50,000 (USD 750.75 to 1501.5) some times. Thus, households rated income gained from eucalypt as 2nd next to *enset*. The increment trend of income generation from the sale of eucalypt is attributable to its fast growth, availability of road network, better market facility and attractive price value. Thus based on the findings of the study, the following practical and policy recommendations are forwarded.

- establishing furniture, asbestos, plywood, pulp, insecticides and pesticides, detergent oil, menthol candy, and medicinal herb factories using eucalypt as raw materials;
- harmonizing indigenous and modern farm practices to scale-up livelihood status;
- giving training to farmers on ideal land use allocation based on their possession;
- conducting in-depth participatory research on blending, proper site and
- ratifying and promulgating specific policy on eucalypt plantations.

## Declarations

### Ethics approval and consent to participate

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Consent for publication

The authors agreed up on the publication of the manuscript.

### Competing interest

The authors declared there is no competing interest.

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### Authors' contributions

The first author prepared the first draft. All other authors read, review and approve the manuscript.

### Availability of data and material

The data and materials used in this research are available and included in the methods

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## Figures

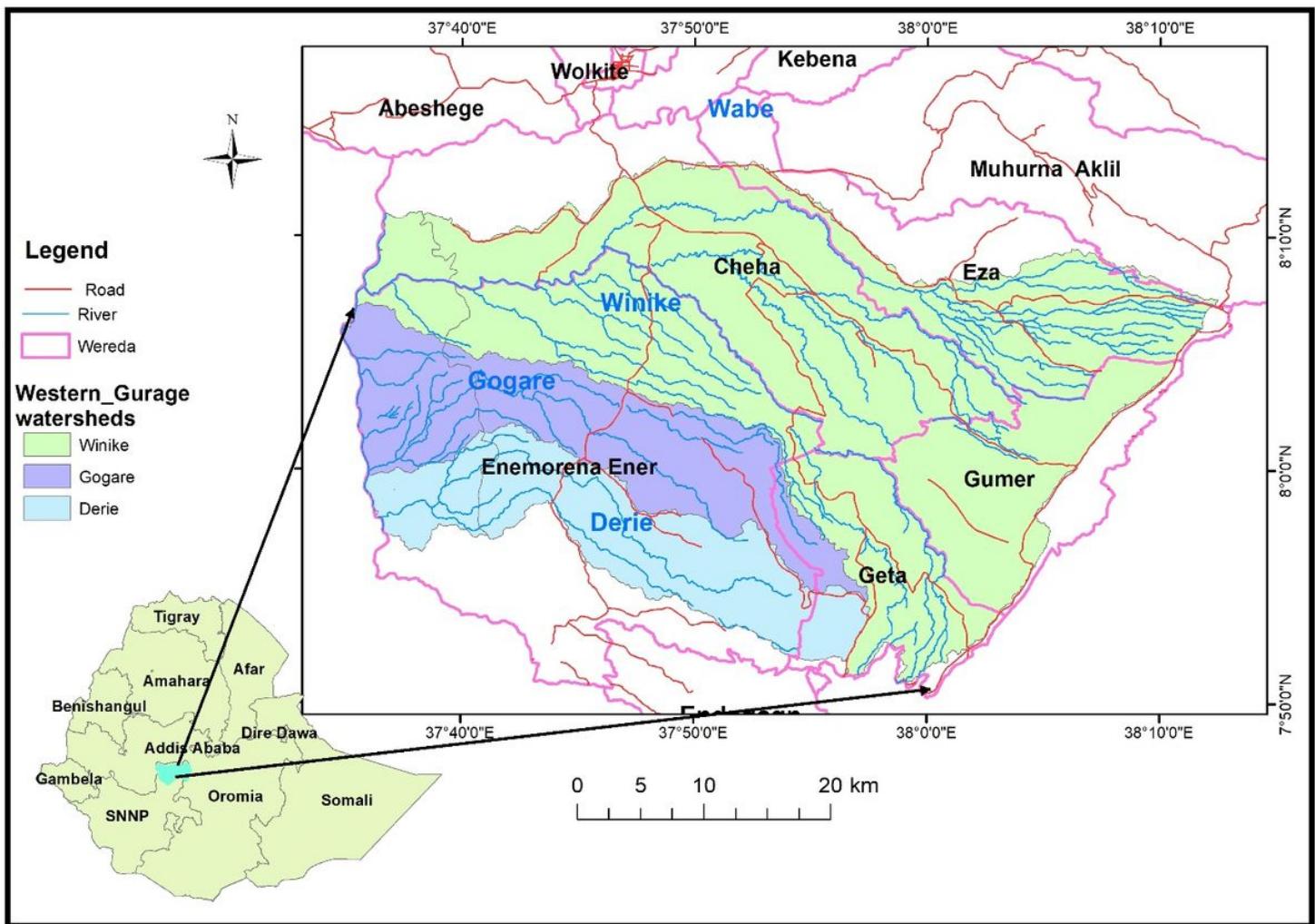
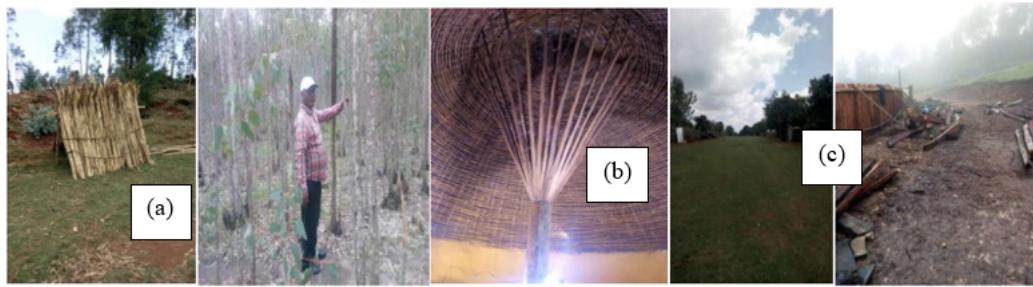


Figure 1

Location map of the Western Gurage Watersheds.



**Figure 2**

The primary needs of eucalypt plantations (firewood (a), poles for construction (b) & soil and water conservation.