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Expansion of on-farm plantation of Eucalyptus Saligna tree and associated Nutrients cultivated in Gambo Watershed, Arsi Zone of Oromia Region, Ethiopia

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Eucalyptus saligna is one of the exotic tree species in Ethiopia. Small scale farmers in Ethiopia plants Eucalyptus saligna widely compared to other tree species. The major objective of the study was to assess the reasons for the expansion of on-farm plantation of Eucalyptus saligna and its associated nutrient export in Gambo watershed, Arsi Zone Oromia region, Ethiopia. Three Kebeles (Ashoka, Gambiltu and Lepis) were selected purposively from the Gambo watershed. Formal survey was carried out on a total of 117 HHs selected by random sampling procedure. Both quantitative and qualitative data were collected through key informant interview, focus group discussion, and household survey, respectively. For nutrient analysis, representative samples from each tree segment (leaf, branch and stem) of different age categories were taken, and diameter at breast height and height were collected from the nine 10*10 m^2 sample plots for aboveground biomass. The results revealed that the main reasons for increased on farm plantation of Eucalyptus saligna were for construction material, income generation, fuel wood, to drain marsh land and for soil and water conservation. The stem of Eucalyptus saligna contains high amount of aboveground biomass. The macro-nutrient concentrations (N, P, K, Ca, and Mg) in above-ground tree biomass showed significant differences between tree components. The nutrient concentrations were highest in foliage, while the lowest concentrations obtained in steam and branch tree parts. Harvesting the biomass of whole trees may have a considerable impact on the nutrient export. Therefore, maintaining the aboveground litter fall on the site would minimize nutrient removal.

Key words: *Aboveground biomass, Eucalyptus saligna, Nutrient, Plantation, on-farm*

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INTRODUCTION

In Ethiopia, due to over population and the associated poverty, there has been an ever escalating deforestation of natural forests. This deforestation caused wood shortage for firewood and construction in the highlands of Ethiopia. Suffering from wood products scarcity and tree-less landscape surrounding in the then newly established capital city, Addis Ababa, Minilik II introduced fast growing *Eucalyptus* in 1895 (Zenebe, 2010). The *Eucalyptus* species were preferred over other species due to a number of merits: it can be used for fuelwood, poles, construction material, pulp wood, timber, raw material for many industrial uses, essential oils, medicine, tannin, for fiber and particle board, and for honey production (FAO, 1979; FAO, 1985; FAO, 2005). Thus it is important for livelihood support and for employment.

Many farmers describe eucalypts as 'life savior', 'safety net,' or 'tree bank' as it is converted easily and quickly to cash whenever needed (Alemu *et al.,* 2005). Similarly Zenebe *et al*. (2007) reported that farmers in central Ethiopia plant *Eucalyptus* tree, particularly *Eucalyptus saligna,* due to increasing demand for wood products, shortage of fuel wood, their high rates of biomass production, ease of plantation and adaptability, non-palatability to livestock, the decline in agricultural land productivity, and the decline in off -farm employment opportunities.

Planting *Eucalyptus* tree has a persistence effect on the land use of both temperate and tropical areas by affecting the microclimate condition, decreasing soil fertility, attracting seed dispersers and depressing competitive grasses (Mulugeta and Demel, 2005; Mulugeta *et al*., 2004). Yeshanew *et al.* (2005) revealed that large areas of the ground surface beneath the *Eucalyptus* remains completely bare and the ground vegetation is very limited in extent. There is high expansion of *Eucalyptus saligna* species regardless of land use considerations in the study area; this has brought a land use competition and different ecological constraints. Besides, our study was conducted to assess reasons for the expansion of on-farm *Eucalyptus saligna* plantation and associated nutrient export. Specifically it was aimed to (1) assess farmers' rationale behind planting *Eucalyptus saligna*, and (2) to assess the associated nutrient export with increased *Eucalyptus saligna* plantation.

MATERIAL AND METHODS

Study site Description

The study was conducted in Gambo watershed, Arsi Zone Oromia region, Ethiopia. It is 220km south of the capital city, Addis Ababa, close to the Rift Valley Eastern escarpment. Geographically it is located at 07^0 09' N 38^0 25' E and 07^0 19' N 38^0 45'E coordinates at an elevation of 2138m.a.s.l, while the topography is slightly undulating especially in the highlands and almost flat in the lowlands. Wheat and barley are the most dominantly cultivated cereal crops. It has an average of 1200 mm and 20 C^o mean annual rainfall and temperature respectively.

The soils are classified as Humic Haplustands or Mollic Andosols with their parent material originating from volcanic lavas, ashes and pumices (FAO, 1986). Even though, mixed agricultural production system is practiced, cereal crop production is the dominant means of livelihood in the area (Asferachew, 2004).

Study site and sample household selection

The Gambo watershed was selected purposively by considering the expansion of *Eucalyptus saligna* plantation on farm land. Three kebeles (*Lepis, Ashoka, and Gambiltu*) among the kebeles in the watershed were also selected purposively by considering the existence of intensive plantation of *Eucalyptus saligna*. Individual households in the area were selected using simplified formula (Yemane, 1967). (See Figure 1)

$$n = \frac{N}{1+N(e)^2} \quad \text{---------------------------------} (1)$$

Where n is the sample size, N is the population size (total household heads size (2269)), and e is the level of precision. Accordingly, 117 HHs were randomly sampled to collect qualitative and quantitative data. Key Informants were selected by adapting snow-ball method (Bryman (2003); accordingly, 4-6 key informants were selected from each kebele. One focus group discussion was established in each *kebele.* Each group included six to seven members.

DATA COLLECTION METHODS

A Combination of both primary and secondary data collection methods were used in this study. The primary data collection started with a preliminary survey followed by a key informant interview, focus group discussions, and household survey by using structured and semi structured questionnaires.

The secondary data were obtained from the Woreda bureau of agriculture and rural development department documentations, reports related to *Eucalyptus saligna* plantation activities and other relevant literature used to gather information about the socio-economic, demographic, location, climatic, edaphic and vegetation characteristics of the study area.

Determination and analysis of aboveground biomass nutrients in *Eucalyptus saligna*

The aboveground biomass was estimated by measuring

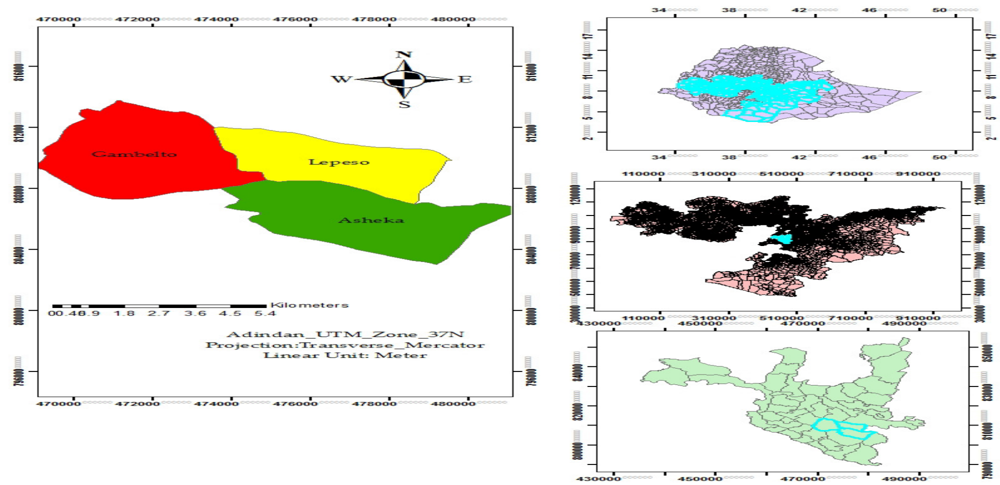

Figure 1. Map of the study site

diameter at breast height (DBH) and height of all trees on a 10*10 m^2 from nine sample plots, three from each kebele. The ages of the stand was ranges between four up to eight; the reasons for the selection of these ages was, it is the most common ages at which most of the farmers harvest for different purposes in the area. Aboveground biomass was estimated by adopting the dry weight predictive allometric equation which was developed based on the height (m) and DBH (cm). The equation was developed as a regression equation by using natural logarithm transformed dry weights (kg) of the different components (Woldeyohanes, 2010).

$$\ln W = \ln b_0 + b_1 \ln DBH + b_2 \ln H \qquad (2)$$

Where W- dry weight of *Eucalyptus saligna* (Kg), ln- natural logarithm, b_o, b_1 and b_2 are the regression coefficients estimated from the data.

The elemental analysis was carried out by focusing some of the macronutrients (N, P, K, Mg and Ca). After felling the randomly selected trees in each stand, they were separated into boles, branches and leaves as suggested by Asferachew (2004). Each bole was cut into 2 m log and disc with 5 cm length was cut from each log. The branches were sub-sampled as upper, medium and lower for biomass and nutrient analysis. Then all the discs and branches were dried at 105˚C until it get constant weight. Foliage was harvested from different branches at different crown height. All the sub-sampled leaves were dried at 60^0C for about 24 hours. The dried leaf samples were finely ground (40-µm mesh size). 300 mg subsamples were digested in 15 ml of concentrated H_2SO_4 from woody stem, branch and leaf each. Na_2SO_4 added to raise the boiling point, and boiled for 4 hr after clearing to insure complete digestion (Binkley and Ryan, 1998).Then the total capital of (N, P, K, Mg and Ca) in % of dry weight in the stem wood, branches and leaves were determined and converted per hectare basis.

Estimation of carbon stock

The aboveground biomass carbon stock was calculated by assuming that the carbon content is 50% of the total aboveground biomass of *Eucalyptus saligna* (Richter *et al*., 1995; Schroeder, 1992).

Statistical analysis

Excel and SPSS were used to run different statistical procedures for analyzing the social data. The comparison of aboveground biomass macronutrients concentration in tree compartments (leaf, branch and stem) was carried out using the software SAS 9.1 version, and one way ANOVA was computed at $p<0.05$.

RESULTS AND DISCUSSIONS

Reasons for expansion of on-farm *Eucalyptus saligna* plantations

In the study area, the major reasons for planting and expansion of *Eucalyptus saligna* on their farmlands were for construction material, income generation, fuel wood, to drain marsh land and for soil and water conservation (Table 1).

This finding is in line with the findings of Gessesse and Teklu (2011) in East Africa. About 81(69%) households in this study were ranked construction material as their most important reason for planting Eucalypts saligna plantations (Table 1). This shows that the majority of the farmers get wood for the construction material from their own land. Farmers use *Eucalyptus* for fuel wood, fence and construction of houses or to generate income by selling parts or the whole tree. *Eucalyptus saligna* is more attractive to farmers due to its' high profitability, multiple uses and generation of quick return than other tree species. It can be grown on degraded land; it is easily cultivated and gives high amount of biomass suitable for construction and energy purposes. Its' nature of regeneration by coppicing was also attractive to farmers. This is in line with Tolla (2010) in Mulo district in central Oromia. Most of the farmers (72%) in the study area converted part of their agricultural lands into *Eucalyptus* plantations for different reasons: (1) when the yield from agricultural fields declined, (2) due to high requirements and high cost of fertilizer for agricultural crop, and (3) due to the influences' of neighbor farmers.

Ways of optimizing the product both from agricultural land and *Eucalyptus saligna* tree

The different ways to optimize the product from *Eucalyptus saligna* and agricultural land in the study area were short term rotation, digging channel to prevent the growth of roots to agricultural land, creating buffer zone between *Eucalyptus saligna* plantation and agricultural land by planting nitrogen fixing shrubs and trees (such as Albizia and Acacia), and mixed planting of *Eucalyptus saligna* with other tree species (Table 2).

Majority of the farmers (87.2%) in study site were using channel digging to reduce the competition of *Eucalyptus saligna* for nutrient and water by hindering the entrance of lateral roots to top soil of proximate agricultural lands (Table 2). To improve sustainability and at the same time increase production, mixing *Eucalyptus saligna* with other tree species could be another possible option. Mixing *Eucalyptus* with other tree species (like Albizia gummifera and Acacia tortilis) can help smallholders to increase the yield of their woodlots in support of their livelihood on a more sustainable basis (Calder *et al*., 1993). This is in line with the findings of Forrester *et al.* (2005) on comparison of monocultures of *E. globulus* (E) and *Acacia mearnsii* (A) and mixtures of these species planted in a species replacement series: 100% E, 75% E + 25% A, 50% E + 50% A, 25% E + 75% A, and 100% A; revealed that mixing *A. mearnsii* with *E. globulus* increased the quantity and rates of N and P cycled through aboveground litter-fall when compared with E. globules monocultures and mixed-species plantations appeared to be a valid system to improve nutrition of eucalypts without fertilization. Short term rotation is another most important practice that large number of farmers (82%) were applying to optimize the product (Table 2). Studies summarized that young *Eucalyptus* plantation does not show any difference for uptake of water in a dry area up to three meter depth compared to indigenous plant species (Wang *et al*., 1991; Amare, 2002). Creating buffer zone is another practice applied by some farmers (58%) to create gap between *Eucalyptus saligna* and agricultural land (Table 2). They let about 8m between *Eucalyptus saligna* stand and agricultural land and they plant nitrogen fixing shrubs and tree like *Albizia, Acacia, and Croton*. Those trees provide basically two functions: they add fertility to the agricultural land and the big trees prevent the leaves of *Eucalyptus saligna* not to fall on agricultural land.

The aboveground biomass and Carbon stock of *Eucalyptus saligna*

The mean total above-ground biomass values of *Eucalyptus saligna* in the study area was 9.446 ton ha^{-1}(Table 3). Stem biomass accounted for the largest share (57%) followed by branch (31%) and leaves (12%), respectively (Table 3). In the three sample plots the tree biomass was allocated as follows: stem > branch > leaf.

The mean total above-ground carbon stock values of *Eucalyptus saligna* in the study area was 4.723 ton ha^{-1} (Table 4). The high amount of carbon stock was allocated to stem. Its carbon stock was comprised 57% of total carbon stock, about 31% in branch and about 12% was in leaves (Table 4).

Eucalyptus woodlot has a great role in increasing the carbon stock of the biomass because of its large production of biomass with in short period of time; this is in line with the findings of Selamyihun (2004). *Eucalyptus* is an efficient biomass producer; it can produce more biomass than many other tree species (Gil *et al.,* 2010). It is known that carbon sequestration is proportional to biomass production, which is in line with the current findings.

Nutrient concentration in *Eucalyptus* saligna

Eucalyptus saligna tree leaves had significantly higher concentration of macronutrients Ca, Mg, K and N, except P compared to the branch and stem; while the branches and stems were not significantly different in nutrient concentrations (Table 5).

The amount of nutrients in the aboveground biomass of *Eucalyptus saligna*

There is significant difference of total nutrient stock in different plant parts (Table 6). The differences may be

Table 1: Ranking of objectives for expansion of on-farm Eucalyptus plantations (n= 117)

Objectives for planting	**Respondents objective rank**						
	1	**2**	**3**	**4**	**5**	**Score**	**Rank**
For income generation	32	70	15	0	0	485	2
For construction material	81	32	4	0	0	545	1
For fuel wood	0	14	98	5	0	360	3
To drain marsh land	3	1	0	5	2	31	4
For soil and water conservation	1	0	0	2	0	9	5

Table 2: Ways for optimizing the product both from Eucalyptus saligna and agricultural crops adopted by households in the study area

Ways of optimizing products (n= 117)	**Frequency**	**Percent**
Short term rotation of *Eucalyptus*	96	82
Digging channel	102	87
Creating buffer zone	65	56
Mixed planting of *Eucalyptus* with other tree species	58	50

Table 3: Aboveground biomass (ton ha-1) of the Eucalyptus saligna

Sample plots	**plant parts**			**Total**
	Leaf	**Branch**	**Stem**	
Ashoka	0.900	1.400	2.200	4.500
Gambelto	1.300	2.400	3.900	7.600
Lephisi	0.840	4.900	10.500	16.240
Avg.	**1.013**	**2.900**	**5.533**	**9.446**

Table 4: Carbon stock (ton ha-1) of the Eucalyptus saligna

Sample plots	**plant parts**			**Total**
	Leaf	**Branch**	**Stem**	
Ashoka	0.450	0.700	1.100	2.250
Gamibiltu	0.650	1.200	1.950	3.800
Lephisi	0.420	2.450	5.250	8.120
Avg.	**0.507**	**1.450**	**2.767**	**4.723**

Table 5: Mean nutrient concentration (SD) in different parts of Eucalyptus saligna

Plant parts	**N (g/Kg)**	**K (g/Kg)**	**P (g/Kg)**	**Ca (g/Kg)**	**Mg (g/Kg)**
Branch	4.43(1.68)^{b}	1.24(0.14)^{b}	0.67(0.26)^{a}	0.88(0.08)^{b}	0.35(0.03)^{b}
Leaf	18(9.91)^{a}	4.58(0.41)^{a}	1.45(0.27)^{a}	1.46(0.16)^{a}	0.53(0.05)^{a}
Stem	4.03(1.37)^{b}	1.28(0.31)^{b}	1.07(0.57)^{a}	0.82(0.06)^{b}	0.29(0.01)^{b}
LSD	**10.68**	**0.77**	**0.99**	**0.27**	**0.08**

Columns followed by different letters are significantly different $p<0.05$

Table 6: Estimated total nutrient stock in different plant parts

Plant parts	Av.Dry biomass(Kg/ha)	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	Ca (Kg/ha)	Mg (Kg/ha)
Leaf	**1013**	18.23	1.47	4.64	1.48	0.54
Branch	**2900**	12.85	1.94	3.60	2.60	1.02
Stem	**5533**	22.30	5.92	7.08	4.54	1.60
Total amount (Kg/ha)		**53.38**	**9.33**	**15.32**	**8.62**	**3.16**

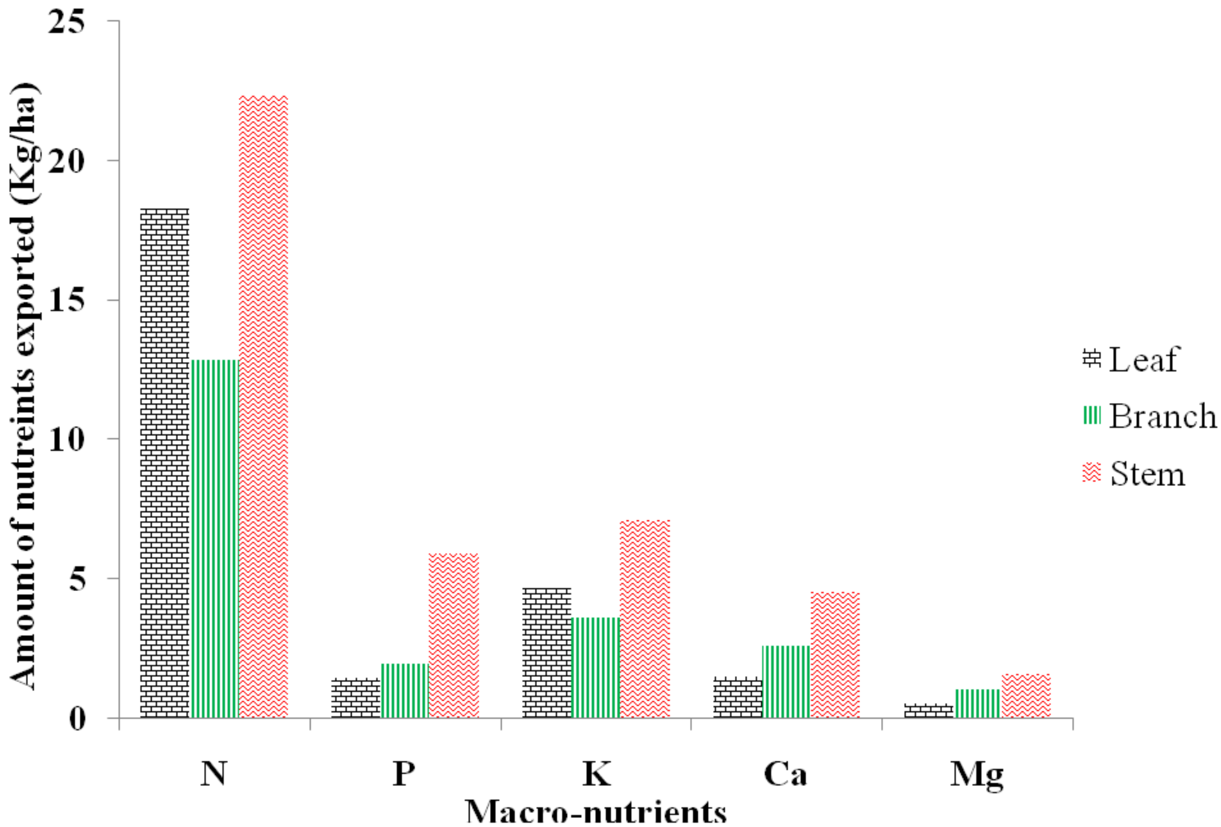

Figure 2: Comparison of nutrient export from different plant parts of *Eucalyptus saligna* during harvesting time.

related to physiological function of different tissues. This is in line with the finding of Mulugeta (2008) on the *E. globulus* plantation trees: leaves > stem wood > stem bark > twigs > branches. A high proportion of the above-ground biomass is in stem wood so that the frequent harvest of the stem part of *Eucalyptus saligna* tree is more drastic to the soil nutrients depletion. In the table 6, from the total nutrients investigated, 58.22% N, 36.55% P, 53.79% K, 46.15% Ca, 50.32%Na and 49.37% Mg contained in the plant components other than stem. This is in line with the finding of Gil *et al.* (2010) on *E. globulus* indicated that, 67.5% of the N; 33.6% of the P; 56.6% of the K and 59.2% of the Ca were contained in the other components than stem. Hence more can be returned back to the soil through leaving the branch and leaf biomass on the site. By leaving only the leaf, the amount of Ca removal could be as low as 17.17% of whole tree harvesting, of Mg as low as 17.09%; of Na as low as 19.34%, of K as low as 30.29%; of N as low as 34.15%, of p as low as 15.76%. The intensive and regular removal of plantation forest floor litter is an important reason for substantial loss of nutrients from the site (Gil *et al.*, 2010).

Nutrient export from each part during harvesting

The highest amount export of N, P, K, Ca and Mg were found in the stem part followed by the branch whereas highest amount of K and N were found in the stem part followed by the leaves.

The nutrients export during the time of harvesting estimated from each plant parts of the *Eucalyptus* tree were about 17.17% Ca with leaf, 30.16% Ca with branch and 52.67% Ca with stem; about 17.09% Mg with leaf, 32.28% Mg with branch and 50.63% Mg with stem; about 19.34% Na with leaf, 31% Na with branch and 49.68% Na with stem; about 30.29% K with leaf, 23.5% K with branch and 46.21% K with stem; about 34.15% N with leaf, 24.07% N with branch and 41.78% N with stem; about 15.76% P with leaf, 20.79% P with branch and 63.45% P with stem (Figure 2); this in line with the findings of Mulugeta (2008); Gil *et al*., (2010).

CONCLUSION AND RECOMMENDATIONS

Over all we found that the main reasons of farmers for planting *Eucalyptus saligna* on their farm land were for construction material, income generation, fuel wood, to drain marsh land and for soil and water conservation. *Eucalyptus saligna* is an efficient biomass producer; it can produce more biomass. The stem of *Eucalyptus saligna* contains high amount of aboveground biomass. The macro-nutrient concentrations (N, P, K, Ca and Mg) in above-ground tree biomass showed significant differences between tree components. The nutrient concentrations (N, P, K, Ca and Mg) were highest in foliage, while the lowest concentrations obtained in steam and branch tree parts. Therefore, harvesting the biomass of whole trees may have a considerable impact on the nutrient export with biomass. Hence, maintaining the aboveground litter fall, twigs and branches on the site and establish mixed stands of *Eucalyptus saligna* with nitrogen-fixing species would minimize nutrient removal.

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REFERENCES

Adugna T (2008). Farmers' Perception on Soil Erosion and Decision on Land Management in Assosa Woreda, Ethiopia; MSc Thesis, Hawassa Univerisity,Ethiopia.

Alemu G., Cortinas M.N., Wingfield M.J. and Roux J (2005). Charactrerisation of the Coniothyrium stem canker pathogen on Eucalyptus camaldulensis in Ethiopia. CSIRO, Australasian plant pathology, 34, 85-90 pp.

Amare G (2002). Eucalyptus farming in Ethiopia: the case for eucalyptus woodlots in the Amhara region. Ethiopian Society of Soil Science, pp 137-153.

Asferachew A (2004). Sustainable Biomass and Nutrient Studies of Selected Tree Species of Natural and Plantation Forests: Implications Management of the Munessa-Shashemene Forest, Ethiopia. *PhD Thesis* Universitat Bayreuth. 149 pp.

Bryman, Alan. (2003) Social Research Methods. 2nd edition. *Oxford University Press*, Oxford, New York

Calder I.R., Hall R.K. and Prasanna KT (1993). Hydrological impact of Eucalyptus plantation in India. *Journal of Hydrology* (Amsterdam) 150: pp 635–648.

Davidson J. 1995. Ecological aspects of eucalyptus plantations.

FAO (Food and Agriculture Organization) (1979). Eucalyptus for planting. FAO forestry and forest products study No.11. FAO,Rome.

FAO (Food and Agriculture Organization) (1985). The ecological effects of Eucalyptus. FAO Forestry Paper No.59. FAO, Rome.

FAO (Food and Agriculture Organization) (1986). Highland Reclamation Study, Ethiopia (AG: DP/ETH/ 037), vols. 1 and 2. Food and Agricultural Organization of the United Nation, Rome, Italy.

FAO (Food and Agriculture Organization) (2005). The importance of soil organic matter: key to drought – resistant soil and sustained food production, Soils Bulletin 80, FAO, Rome.

Forrester D., Bauhus J., and Cowie A.L (2005). Nutrient cycling in a mixed-species plantation of Eucalyptus globulus and Acacia mearnsii Canadian Journal of Forest Research 35: pp2942–2950.

Gessesse D. and Teklu E. (2011). *Eucalyptus* in East Africa, Socio-economic and environmental issues, Planted Forests and Tress Working Papers, Working Paper FP46/E, Forestry Department, FAO,Rome, Italy.

Gil L., Tadesse W., Tolosana E. & López R. (Eds). (2010). *Eucalyptus* species management, history, status and trends in Ethiopia. Proceedings from the congress held in Addis Ababa. September 15th-17th, 2010. pp 297-309.

Jagger P. and Pender J. (2000). The Role of Trees for Sustainable Management of Less-Favored Lands: the case of Eucalyptus in Ethiopia. International Food Policy Research Institute, EPTD discussion paper 65, Washington, D.C. U.S.A.

Mulugeta L. and Demel T (2005). Effect of Prior land use on the recolonization of native woody species

under plantation forests in the highlands of ethiopia. Foret ecology and Management 218: pp 60-73.
Mulugeta L., Gidyelew T. and Demel T (2004). Effect of canopy cover and understory environment of tree plantation on richness, density and size of colonizing woody species in southern Ethiopia. Forest Ecology and Management. 194: pp 1-10.
Mulugeta Z (2008). Temporal changes of biomass production, soil properties and ground flora in *Eucalyptus globulus* Plantations in the central highlands of Ethiopia. *Doctoral Thesis.* Swedish University of Agricultural Sciences Faculty of Natural Resources and Agri. Sci. Department of Forest Soils Uppsala. 74 pp.
Oballa, P. and Chikamai, B. (2010). Paper to: Validation Workshop of the Report Eucalyptus in East Africa: the socio-economic and environmental issues. Bujumbura, Burundi 31 March-1 April.
Richter D.D., Markewitz D., Dunsomb J.K., Wells C.G., Stuanes A., Allen H.L., Ureego B., Harrison K.& Bonani G. (1995). Carbon cycling in a loblobby pine forest: Implication for the missing carbon sink and for the concept of soil. pp. 223-251. *In*: W.W. McFee & J.L. Kelly (eds.) *Carbon Forms and Function in Forest Soils*. Soil Science Society of America, Madison, WI.
Schroeder P. (1992). Carbon storage potential of short rotation tropical tree plantations. *Forest Ecology and Management* 50: pp31-41.
Selamyihun K. (2004). Using Eucalyptus for Soil and Water Conservation on the Highland vertisols of Ethiopia. PhD Thesis, Wageningen University and Research Center, Wageningen.
Shiferaw A. and Tadesse W (2010). Regeneration of *Coffee arebica* and quality of coffee found in *Eucalyptus grandis* plantation pp. 122-130.
Tolla G. (2010). Expansion of Eucalyptus Plantations by Smallholder farmers amid Natural Forest Depletion: Case study from Mulo District in Central Oromia, Wondo Genet College of Forestry and Natural Resources .Proceeding from the Congress held in Addis Ababa, September 15th-17th 2010.
Wang D., Bormann F.H., Lugo A.E., Bowden R.D. (1991). Comparison of nutrient-use efficiency and biomass production in five tropical tree taxa. For. Ecol. Manage. 46, pp 1-21.
Woldeyohanes F., Ahmad A., Faizah A. H., and Abdul R. (2010). Aboveground Biomass Equations for Selected Eucalyptus species in Ethiopia. Eucalyptus Species Management, History, Status and Trends in Ethiopia. Proceedings from the Congress held in Addis Ababa. September 15th-17th.
Yeshanew A., Zech W. and Guggenbergeri G. (2005). Transformation of a Podocarpus falcatus dominated natural forest in to a monoculture eucalyptus globulus plantation at Munesa, Ethiopia: Soil organic C, N, and S dynamics in primary particle and aggregate- size fractions. Agriculture, Ecosystem and environment, 106: pp 89-98.
Zenebe M. (2010). Community Opinion, Marketing and Current Debates on Eucalyptus in Huruta District, Arsi Zone of Oromia Region, Ethiopia. Eucalyptus Species Management, History, Status and Trends in Ethiopia. Proceedings from the Congress held in Addis Ababa. September 15th-17th, 2010. Pp 131-145.
Zenebe M., Habtemariam K., Mulugeta L. and Campbell B. (2007). The role and management of Eucalyptus in Lode Hetosa District, Central Ethiopia. Forests, Trees and Livelihoods 17 (4): pp 309-323.
Zhang W. (2012). Did Eucalyptus contribute to environment degradation? Implications from a dispute on causes of severe drought in Yunnan and Guizhou, China. School of Life Sciences, Sun Yat-sen University, Guangzhou, China; Environmental Skeptics and Critics, 2012, 1(2): pp34-38.