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Eucalyptus Expansion as Relieving and Provocative Tree in Ethiopia

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Authors' contributions

This work was carried out in collaboration between all authors. Author DJ designed the study, managed the literature searches and wrote the first draft of the manuscript. Author ML edited the procedure. Authors BM, HM and ML edited and reviewed the Manuscript. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Over the last century, *Eucalyptus* has rapidly expanded across the globe. It has become the most planted tree species. Environmentalists fear this for the perceived negative eco-hydrological impact. Foresters and wood industries support its expansion looking at its socio-economic benefits. Ethiopia is one of the countries where *Eucalyptus* dominates forest development gains in the last century. The main purpose of this review is to evaluate the expansion, benefit and challenges of *Eucalyptus* in Ethiopia. *Eucalyptus* was introduced to Africa, and Ethiopia, around the end of the 19th century, in 1890s. Since then it has continued to expand to cover wider geographic areas within Ethiopia: highland and lowland. It is providing multiple purposes, economic and social, for millions of households in urban and rural areas. It has substituted effectively some of the natural forest's functions, principally in wood supply; hence this way it has contributed to reducing pressure and in slowing down deforestation. Yet *Eucalyptus* sustained blame for ecosystem water and soil nutrient drains, and allelopathic effect to suppress native flora growth. Studies on these aspects of

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the genus are inconclusive. Some argue the extravagant use of water and nutrient, while others argue otherwise. There are studies that show water and nutrient use of *Eucalyptus* is based on availability: for instance, dry season and wet season uses are not the same. The most known about *Eucalyptus* is its high nutrient and water use efficiency. Therefore, when evaluated on per volume of water, nutrient and land allocated for biomass production, *Eucalyptus* will provide the highest biomass return. This may make it the preferred species. The paper concludes that the development of *Eucalyptus* forestry is crucial in narrowing the gap between forest product demand and supply in the current context of Ethiopia and most African countries, but such development should be managed with proper silviculture: Planted in the right site and tended properly to optimize its positive values and reduce possible negative effects.

Keywords: Eucalyptus; Ethiopia; plantation; ecosystem; restoration; nutrient; soil and water.

1. INTRODUCTION

Eucalyptus is one of the most planted woody species in the world next to *Pinus* and *Cunninghamia* [1,2]. Eucalyptus belongs to the Myrtaceae family with three genera such as *Eucalyptus*, *Corymbia* and *Angophora*. There are about 900 species, subspecies and hybrids of *Eucalyptus* globally [3]. The original meaning of *Eucalyptus* is 'well covered' as it derived from two Greek words *Eu* and *kalyptos*. More than 700 known *Eucalyptus* species are native to Australia [4]. Outside its natural eco-region, *Eucalyptus* is expanding from 0.7 million ha in 1955 to more than 20 million ha in 2009, distributed to over 100 countries [5,6]. It can grow in tropics, sub tropics and some temperate regions and covers 0.5% of the global surface forest area [7]. *Eucalyptus* is rapidly expanding in India, Brazil, China, South Africa and Australia [8].

The expansion of *Eucalyptus* from Australia to Europe began before 200 years in Portugal [7]. *Eucalyptus* was introduced to United States in the mid nineteenth century. It further distributed to other parts of the world in the late 19th century and the beginning of 20th century when the demand for fuel and energy escalated in Europe, South America, Asia and Africa [7,9].

Eucalyptus is one of the exotic tree species and most successful plant growing on different environments in Ethiopia and broadly in Africa [10]. *Eucalyptus* was planted in Africa initially on the southern African plateaus in the early 19th century to supply fuel wood [11]. During the time, the country has small remnant natural forest thus the only option for fuel wood was *Eucalyptus* [9]. During the colonial time *Eucalyptus* was introduced to Rwanda, Kenya, Uganda, Sudan and Tanzania [2,7,12,13]. In the 1895 the Emperor of Ethiopia introduced the tree from Australia to address the prevailing fuel wood and construction material demand [14]. Still today plantation establishment in Ethiopia is predominantly *Eucalyptus* [15].

The tree of choice for the huge energy demand prevailing in Ethiopia by the time was *Eucalyptus* due to its fast growth and large biomass production. The ability to grow in diversified ecological zone, multi-purpose use, fast biological growth and large biomass production made *Eucalyptus* a preferred species often by many growers [16]. *Eucalyptus* can be used for production of good quality wood materials [4,17,18]. It can also be used for fuel wood and decorative wood production in industry. *Eucalyptus* can be used as conservation tree as wind break, biodiversity conservation and maintenance of ecosystem processes [18-20]. Some species of *Eucalyptus* can be preferred for medicinal use (traditional) and in pharmaceutical industries. *Eucalyptus* can be used as a source of pollen and nectar production for apiary industries [4].

In the phase of persistent controversies, the species is expanding faster than ever in Ethiopia. Additional evidences on ecological, social and economic importance of the species are also emerged in most part of the globe [21-24]. However, as far as we know no attempt is made to review recently research findings and synthesize this into a policy guide. The main purpose of this review is therefore to evaluate the expansion, benefit and challenges of *Eucalyptus* in Ethiopia.

2. EXPANSE OF *EUCALYPTUS* IN ETHIOPIA

As stated above *Eucalyptus* is the first species introduced to Ethiopia and used in reforestation/afforestation program. The species was introduced over 140 years ago. Today, it is the most planted species of all, and in recent

decades planting of the species spread widely through small holders' woodlot plantation (Fig. 1). Its expansion, besides its biological merits, is also driven by growing wood product demand and growing price [25]. Recent expansion includes replacement of croplands with *Eucalyptus* woodlots across highlands of Ethiopia [13,26]. *E. globules* and *E. camaldulensis* are the two dominantly spreading species among nearly 60 different species (Table 1) of the genus introduced to Ethiopia [27]. Growing *Eucalyptus* as one of the land use at small scale farm level is popular in the highlands of Ethiopia [28].

The estimated mean annual increment of *Eucalyptus* woodlots in Ethiopia are 10-20 m^3/ha/year, which is higher than the average yield from plantation forests that is estimated at 10-14 m^3/ha/year [15]. This characteristics of high yield provider per year per hectare attracted farmers to plant more every year which has led to expand more in the highlands of Ethiopia [30,31]. The other attractive characteristic of *Eucalyptus* tree which has led to more expand is the short rotation period that it need as compared to many other coniferous plantation which ranges from 10 to 18 years depending on the purpose of planting [15]. *Eucalyptus* can grow in different agro ecological zone, infertile soils and heavy clays these also fevered the farmers to continue planting *Eucalyptus* [2]. As the result of its fast growing character, less fertility requirements and high revenue, *Eucalyptus* is best fit for highly biomass and construction materials demanding country such as Ethiopia [32].

Table 1. Some of *Eucalyptus* species growing in Ethiopia

E. amygdalina	*E. cornuta*	*E. ficifolia*	*E. maculata*	*E. parvifolia*
E. astringens	*E. crebra*	*E. dalrympleana*	*E. melliodora*	*E. patens*
E. bosistonana	*E. globulus*	*E.gomphocephala*	*E. microcorys*	*E. pilularis*
E. botryoides	*E. deanei*	*E. planchoniana*	*E. microtheca*	*E. goniocalyx*
E. brockwayi	*E. delegatensis*	*E. grandis*	*E. nitens*	*E. regnans*
E. gunnii	*E. diversicolor*	*E. camaldulensis*	*E. obliqua*	*E. resinifera*
E. cinerea	*E. dundasii*	*E. incrassata*	*E. occidentalis*	*E. robusta*
E. citriodora	*E. dunnii*	*E. johnstonii*	*E. ovata*	*E. rubida*
E. cladocalyx	*E. fastigiata*	*E. largiflorens*	*E. paniculata*	*E. saligna*
E. cloeziana	*E. wandoo*	*E. transcontinentalis*	*E. tereticornis*	*E. leucoxylon*
E. salubris	*E. sideroxylon*	*E. salmonophloia*	*E. torelliana*	*E. viminalis*

Source: [29]

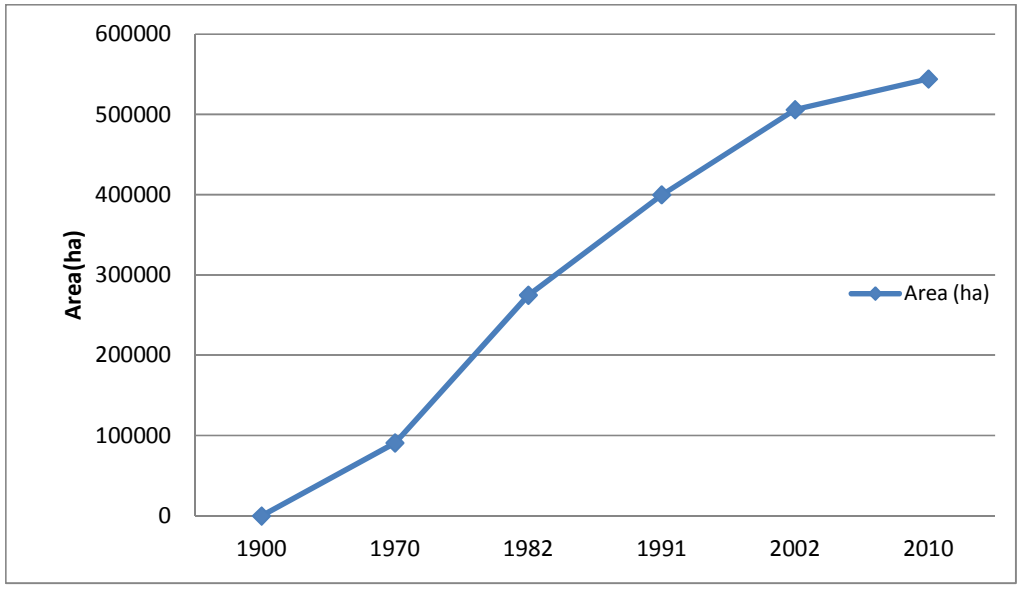

Fig. 1. Temporal distribution of *Eucalyptus* in Ethiopia

Source: [15,19]

The expansion of *Eucalyptus* especially since recent decades has been seen in the highlands of Ethiopia (Fig. 2). It has become the most preferred species for planting by farmers due to its economic benefit and huge demand of wood materials [26,33]. Currently, it is estimated that, over 500000 ha of the land is covered by *Eucalyptus* plantation in Ethiopia [34]. The expansion has also contributed to increase the forest plantation cover from an estimated 190000 ha in 1990 to 972000 ha in 2010 [15]. Likewise, the impact on natural forest has been reduced due to the substitution of natural forest product by *Eucalyptus* product. According to Jagger and Pender [32] *Eucalyptus* expansion is happening not only on forested and grazing land but also it expands from state owned enterprises to community and household ownerships. Fumikazu [35] also argue that the socio economic attributes and the history of the community affect *Eucalyptus* expansion in the area. Still, more expansion of *Eucalyptus* is expected due to the above mentioned reasons. Striving to stop the expansion is not the solution expected from all stakeholders but how to get benefit from the expansion without harming effect should be the way forward.

3. CONTRIBUTION OF *EUCALYPTUS* IN THE FOREST SECTOR OF ETHIOPIA

3.1 Relieving Wood Product Scarcity

Wood from *Eucalyptus* are used as fuel wood, construction material (such as scaffold), in furniture manufacturing, handicrafts, for veneer, poles, piles, girders and pulp and paper [4,18]. The dominant use of *Eucalyptus* in Ethiopia is as fuel wood and construction material. In Ethiopia, where above 90% of the population's energy demand comes from biomass (Table 2), *Eucalyptus* is playing a crucial role in the supply of the much needed energy [36]. For instance, at the local market of *Lode Hitosa*, Ethiopia 78% of the firewood and 20% charcoal are from *Eucalyptus* [37]. Similarly, Bewket [38] found that 80% of the tree planted in *Chemoga* watershed is *Eucalyptus* and above 75% of their fuel wood demand covered by *Eucalyptus*. Likewise, the majority of low income households in *Anget Mewgia* is growing *Eucalyptus* for fuel wood and house construction purpose [39].

Eucalyptus, at some level, has substitute and relieve the wood product demand in Ethiopia. Especially, it can substitute industries' demand for wood product such as lumber, plywood, veneer, poles and pulp [15,40]. The major wood factories in Ethiopia are using in some extent *Eucalyptus* as row materials [15]. The household consumption of wood product is also growing as the population size growing. With the alarming population growth in Ethiopia, the consumption of fuel wood and construction material at household level will not be manageable by harvesting large amount of natural forest or plantation with the absence of *Eucalyptus*. The remaining closed natural forest in Ethiopia is below 3.37% [15] which is also found in some remote areas, it is believed that the burden on the natural forest and woodland were minimized by the plantation forest especially by *Eucalyptus* plantations and woodlots in the country.

3.2 Landscape Re-greening

Re-greening is the process of planting and managing trees on degraded or previously forested areas. Re-greening was started in Ethiopia in the 1890s through the government of Ethiopia by planting *Eucalyptus* in and around the capital for fuel wood and construction material [27]. Then after small scale plantations were also encouraged since 1970 by the government and still today planting trees on degraded areas is favored [15]. Re-greening in Ethiopia mainly encompass two types of conservation activities that are area exclosure and reforestation and afforestation [27].The former mostly practiced by NGO and states while the latter is mostly practiced by the small scale farmers and wood industries. Among the four genera mostly used for reforestation and afforestation in Ethiopia *Eucalyptus* takes the lion share [15,27]. It's fast growing, adoptability in harsh condition and unpalatable to browsers has made it the most selected species for landscape re-greening in Ethiopia [32]. Planting *Eucalyptus* for re-greening has two major significant benefit one environmentally and the other is socio economically. The farmers are encouraged to continue planting *Eucalyptus* indirectly because they are benefited from the income generated from wood products with less limitation of forest policy which hinders cutting and using indigenous tree because it is not among the five prohibited indigenous trees in Ethiopia [27]. So that planting *Eucalyptus* is like gaining two benefits by one goal as re-greening.

3.3 Contribution to Poverty Reduction

In the country where 85% of the population is depending on subsistence agriculture which is

Table 2. Household distribution by type of fuel used for cooking in Ethiopia (2011)

No	Type of fuel	Rural (%)	Urban (%)	Country (%)
1	Fire wood	91.8	53.7	85
2	Charcoal	0.2	17.5	3.9
3	Leaves/Dung cakes	8.4	2.7	7.2
4	Kerosene	0.2	4.9	1.2

Source: [36]

mainly backward farming, poverty reduction and food security is major concern and target for policy makers and government in general. *Eucalyptus* significantly contributes to the household income improvement that leads to poverty reduction [37,39]. In *Eucalyptus* planted areas, it is the largest nonagricultural source of household income [32,39]. According to the study by Mekonnen et al. [37] the income from *Eucalyptus* contributes up to 72% of total household annual cash income for poor household in central highland of Ethiopia. The income generated from *Eucalyptus* sale can be used to buy food and other household expenses. Similarly, the fuel wood that is used for household consumption was not converted to price, but it has significant impact on poverty reduction and women empowerment. In most rural areas of Ethiopia women took their major time in collecting fuel wood far places from their villages. If the time and man power invested on fuel wood collection were determined, the value generated from *Eucalyptus* might raise higher. Kebebew and Ayele [28] has indicated that about half of the household income relative to major agriculture crops were generated from *Eucalyptus* and small holder farmers are practicing *Eucalyptus* planting as important land use option at the farm level. Similarly, Kebebew and Ayele [28] argued that assigning 12% of the land to *Eucalyptus* can increase the income from the land up to 90% and reversely substituting the *Eucalyptus* covered land by important crops such as *teff* and barley may reduce the income from the land up to 125%. In general, practicing *Eucalyptus* planting as one land use besides cultivating other crops in the available field could improve the household income and contribute to poverty reduction straggle in Ethiopia.

3.4 *Eucalyptus* as Foster Ecosystem and Biodiversity Conservation/Restoration

Mostly, *Eucalyptus* is feared for ecological hazardous and ecosystem destructor, but *Eucalyptus* is an important tree in fostering ecosystem serving as conservation tree at beginning of restoration process of degraded sites. *Eucalyptus* plantations in southern Ethiopia were used as a buffer for degrading natural forest and have reduced impact on the forest [20]. It is substituting the fuel wood and construction materials harvested from natural forest which previously lead to deforestation due to the huge gap of demand and supply without the presence of this species [10,13,41]. The *Eucalyptus* planation has reduced natural forest deforestation in one way and reduced human impact in other hand that provide time for natural forest regeneration and allow improvement of biodiversity richness. The study has indicated that *Eucalyptus* plantations facilitates that the process of forest succession by providing a nurse effect for the colonizing native species and attracted seed dispersal agents [20]. Additionally, *Eucalyptus* plantations can be used to foster natural forest re-colonization and successional process [20,42]. Similarly, it can also facilitate the regeneration of native woody species in the plantation through reducing soil erosion and facilitating attractive conditions for seed germination [42]. In addition, *Eucalyptus* plantation can also foster the regeneration of other native woody species in degraded area by providing protection [16,43,44].

Studies have indicated that land use change from *Eucalyptus* to cropland is possible with some nutrient benefit anytime when the farmer needs to shift to croplands [45]. On the contrary to controversial studies mentioned about *Eucalyptus*, the land which was under *Eucalyptus* is better in soil chemical properties. Similarly, the total nitrogen was also greater in *Eucalyptus* land use than the others [45]. According to Davidson [46] the water efficiency of *Eucalyptus* is greater than some other field crops in Ethiopia. Likewise, the farmers also perceive the land use under *Eucalyptus* was better and changing *Eucalyptus* to cropland without affecting soil properties is possible [45].

The study that has investigated the effect of *Eucalyptus* plantation before and after clear felling in the highland of Ethiopia has revealed that, cropland dry matter production was lower as

compared to the *Eucalyptus* clear felled land and it also supported by the farmers response [47]. Apart from the rumors and some findings, the above mentioned study encourage growing crops on previously *Eucalyptus* cleared felled land will benefit the farmers providing good yield. Zegeye [10] argue that the negative effects of *Eucalyptus* were as a result of poor management than its biological behaviors and insisted that it can provide many more environmental and socioeconomic benefit than the negative ecological effects. It is also possible to grow other trees or crops on the harvested *Eucalyptus* field. Indeed, *Eucalyptus* would be able to foster ecosystem if the species carefully identified and managed based on the knowledge of the species effects on local biodiversity and the soil [42]. As far as the above listed studies and our knowledge concerned, Eucalyptus plantation could foster the biodiversity, reduce deforestation of natural forest by providing enough supply of fuel wood and construction material, protect the soil surface from direct raindrops and reduce carbon emission. In conclusion, *Eucalyptus* is nature friendly tree but not destructor in many angles. However, further detailed investigations should be done on its effect on ecosystem to provide clear information for interested policy makers.

3.5 Social and Cultural Value

Eucalyptus planting was one economic rational response to the recent changes in the rural economic environments caused by rapid economic growth in rural community [35]. In Ethiopia, the farmers continue planting *Eucalyptus* because of its cash income apart the perceived advert effect on soil and water [48]. The regional government of *Tigria* in Ethiopia has banned planting *Eucalyptus* due to its suspected effect but later recently rejected the ban after realizing the tree was yielding higher revenue in the region [32]. Beside the above, planting *Eucalyptus* is less costly than other growing agriculture crops in Ethiopia. The labor cost is only at planting, thinning and harvesting period which is once every 3 to 9 years. *Eucalyptus* woodlot provides both environmental and exchange entitlements to the local people [49]. Through planting *Eucalyptus*, environment entitlements such as firewood, medicinal collections, *Eucalyptus* seeds and exchange entitlements such as paid labor for different activities in the plantation and trading the products can be acquired. Generally, social and environment services can be changed to better position in such a way that livelihoods and natural forests improved through plantation [49,50]. In some community of Ethiopia having *Eucalyptus* woodlots provide some social status in the society. Having *Eucalyptus* woodlots can also reduce women and children fuel wood collection time and energy and indirectly allows children to invest their time on their education.

4. *EUCALYPTUS* AS CONTROVERSIAL SPECIES

4.1 Water Consumption

Eucalyptus has taken the vast area of the world and raising fears over water resources and Eco hydrological effects [6]. Similarly, *Eucalyptus* is widely expanding throughout Ethiopia and it is also continuing as most controversial tree species among environment related scientist and socio economists due to the dilemma of its environmental effect and tree product benefits [51]. Bewket and Sterk [52] indicated that among other types of land use changes, *Eucalyptus* and land degradation in the highlands of Ethiopia lead to the decrease stream flow more clearly in the drier season. Similarly, Chanie [48] reported farmers' response as *Eucalyptus* dries up springs in the highlands. *Eucalyptus* is known by its high transpiration rate ranged from 0.5 to 6.0 mm per day and also believed that *Eucalyptus* plantations may extract water from shallow ground water [6]. Soils were drier in the *Eucalyptus* up to 3m than other vegetation cover and it has indicated that vegetation changes affect evapotranspiration, water yield flooded area, water balance and other hydrologic variable [53]. On the contrary, *Eucalyptus* is water efficient tree species than other crops though *Eucalyptus* is perceived as high water consumer by some environmentalist [41,51]. Most *Eucalyptus* species averagely use 785 liter of water to produce 1 kg of biomass [46]. This is far smaller than potato, soya bean, sorghum and maize (Fig. 2). According to Davidson [46] some *Eucalyptus* species even not consume extra water from the deep ground excess than the rainfall of the western highland of Ethiopia. Further studies should be done on the effect of *Eucalyptus* plantations on runoff and sediment yield at field scale in order clarify the rumors on *Eucalyptus* water and nutrient consumption.

4.2 Biodiversity Impact

Eucalyptus is widely considered to have some allelopathic effect which reduced the biodiversity under the *Eucalyptus* plantation. The studies

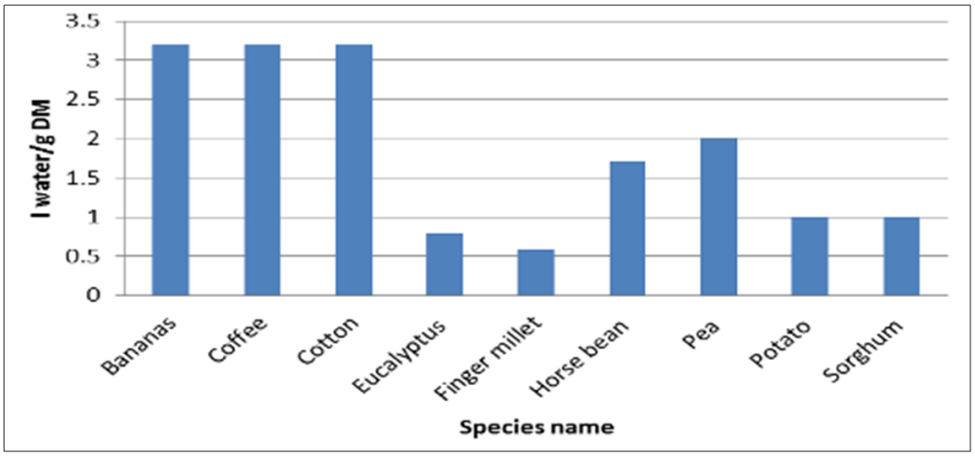

Fig. 2. Water use efficiency *of Eucalyptus* and other species
Source [54]

related to *Eucalyptus's* allelophatic effect were done mostly in the laboratory, which does not perfectly represent the actual ecosystem. According to Chu [55] the root length of the native species was significantly inhibited in *Eucalyptus* plantations compared to other plantations, but the study concluded that allelopathy in the *Eucalyptus* plantations is selective. *Eucalyptus* has significant inhibitory effect on germination, root, shot elongation of tomato plants [56]. Biodiversity of the wetlands were declined as the result of land use conversion to mainly *Eucalyptus* [57]. Similarly, Chanie [48] has indicated that *Eucalyptus* decreases maize yield within 20 m radius from the trees and soil become water repellent which might has effect on other plant growth. Planting tomatoes under *Eucalyptus* is not recommendable [56]. On contrary to the above, *Eucalyptus* has potential in encouraging the recruitment, establishment and successions of native species, which promote biodiversity improvement [20,58]. Regeneration of *Junipers procera* on previously *Eucalyptus* plantation was also possible at *Entoto*, Ethiopia, which has shown wrong believes that planting other trees after harvesting *Eucalyptus* is not possible [59]. Fikreyesus et al. [56] has given remedies for the allelopathic effect of *Eucalyptus* on tomatoes by removal of excess leaf litters and planting after rains. Chanie [48] has also recommended that planting crops such as maize by providing 20 m gap from *Eucalyptus* tree is possible. As another option the introduction of nitrogen fixing species could be the potential choice for the establishment of mixed stand with *Eucalyptus* [55]. Allelopathic effect of *Eucalyptus* was not tested on the field. However, most of the studies have tried to investigate its effect at plot size in greenhouse. These studies could not verified that *Eucalyptus* has allopathic effect at field scale so that, further field research on allelopathic and related effect of *Eucalyptus* should be done.

4.3 Soil Degradation

Eucalyptus is blamed for heavy use of soil moisture, leaf litter and soil humus, consumption of soil nutrients, less soil conservative, non-fodder and habitat [13]. Studies by Kidanu [60], Bargali et al. [61], Chanie [48] argued that *Eucalyptus* decreases soil nutrients within 20 m distance from the trees (Table 3). The comparison study of *Eucalyptus* with mixed plantation has revealed that *Eucalyptus* has three times more fine root biomass in surface soil which indicated that planting crops in association and adjacent to *Eucalyptus* should be avoided [62]. However, *Eucalyptus* species exceptionally can extend the nutrient cycling deep to ground soil where other trees and crop could not access that much depth [43]. The wetland conversion study has indicated that there is significant deference between wetlands and converted land to dominantly *Eucalyptus* by reducing major nutrients from the converted land which is *Eucalyptus* [57]. Similarly, Soil nutrient and carbon pool under *Eucalyptus* is lower than the mixed plantation [62]. In addition to the above, the soil under *Eucalyptus* becomes water repellent and the perceptions of the local farmers agreed with the experimental findings by reducing the crop productivity of the land [48]. On contrary to the above, Tadele et al. [47] has

found that the maize dry matter production and grain yield planted on cleared felled *Eucalyptus* stand are significantly higher than adjacent field. According to Hailu et al. [43] *Eucalyptus* does not over exploit the soil than the traditional fuel usage such as litter and cow dung collection. Similarly, the study has indicated that due to non-browsed characteristics of *Eucalyptus* than other fodder tree, it is well fitted for soil protection purposes if it is incorporated with avoidance of liter and bark collection in overgrazing practiced places. Generally, there is lack of clear scientific evidence that shows *Eucalyptus* impact on soil nutrient that lead to soil degradation. Further research should be done on *Eucalyptus* species impact on soil in Ethiopia.

5. DISCUSSION AND IMPLICATIONS

The expansion of *Eucalyptus* is not going on similar trend as it was expected. *Eucalyptus* is expanding very rapidly from place to place in Ethiopia. Eventually, it is also taking some fertile places for crops in the highland of Ethiopia. More than half million hectares of land are covered by industrial and woodlots *Eucalyptus* in Ethiopia. This number varies from regions to regions but the number could escalate in the coming years. *Eucalyptus* contributes for the forest sector of Ethiopia. Planting *Eucalyptus* in various part of the country has relieved the wood product scarcity in Ethiopia in some extent. If *Eucalyptus* were not introduced in the country before the century, it could have been no natural forest cover seen currently. It is still taking the lion share by providing fuel wood, construction material, industrial wood and other wood and non-timber products in Ethiopia. *Eucalyptus* also significantly contributes for land re-greening. More than half Ethiopia's plantation is covered by *Eucalyptus*. Still many mountains and hills were covered by *Eucalyptus* in the country. Indeed, *Eucalyptus* has also contributed to poverty reduction. Many farmers are growing *Eucalyptus* for the purpose of income generation. The *Eucalyptus* products could be sold and provide revenue. The income generated from *Eucalyptus* could improve livelihood of subsistence farmer and contributed for poverty reduction. *Eucalyptus* growers' income has grown after they started planting. *Eucalyptus* also contributes for fostering ecosystem and biodiversity conservation. It has given protection for under growing fauna and flora. *Eucalyptus* has also protected the soil from severe erosion by providing cover from direct rain drop. It has also provided buffer for high forest and susceptible forest. Having *Eucalyptus* woodlots or plantation has also given social and cultural value in Ethiopia. Some entitlements haves also provided to the farmers through planting *Eucalyptus*. In rural community of Ethiopia planting *Eucalyptus* has gained social respect and value in the community. In general, planting *Eucalyptus* in developing countries could have many more advantages for the ecology, for the societies and even for the country's economy.

Eucalyptus often blamed for its controversial effects on soil, water and biodiversity. Many blame *Eucalyptus* for its water consumption but *Eucalyptus* is known for efficient water user. *Eucalyptus* has used water from deep using its roots. Even as comparing with other crops *Eucalyptus* use less water to produce a kilogram of biomass as compared to other species. There is no concrete evidence on high consumption of water than people perceptions. The other point that *Eucalyptus* mostly blamed for its allelopathic effect, but most allelopathic studies on *Eucalyptus* have been done in green house or laboratory that mostly could not express the

Table 3. Soil nutrients condition under *Eucalyptus* and other species

Soil properties	*Eucalyptus*	*C. lusitanica*	*C. macrostachyus*	*C. africana*	Reference
Soil pH	*/**		-	-	[48,61,63]
Moisture content	**		*	-	[48,61]
Soil texture and bulk density	*	**	*	-	[48,61,63]
Organic C	**	**	**	**	[48,61,62,63,64]
Total N	**	**	**	**	[61,62,63,64]
Available P	**	**	**	**	[48,61,62,63]
Exch.Ca and Mg	**	**	-	-	[48,61,63]
Exch. K	*/ **	**	**	**	[48,61,62,63]
Available S	**	-	-	-	[64]

***** *Not changed; ** changed*

Eucalyptus field allelophatic effect. So, clearly field research is needed to discuss about *Eucalyptus* allelophatic effect. The other blaming point is *Eucalyptus* soil nutrient consumption this is also more biased part of *Eucalyptus*. *Eucalyptus* is one of the fast growing species so, it can compete for the nutrients thus it is advisable to plant crops far from the tree as it compete for nutrients as any other tree species.

6. CONCLUSION AND POLICY RECOMMENDATION

Studies which are blaming *Eucalyptus* for water and soil nutrient consumption, allelophatic effect are inconclusive. The most known of all about *Eucalyptus* is its high nutrient and water use efficiency compared to most other tree species and field crops. Therefore, *Eucalyptus* will provide the highest return when it compared with most indigenous species on per volume of biomass production. It is better to avoid the general blind dislikes and fears against *Eucalyptus* among professionals and farmers. Proper decisions to continue planting or not should be given at local level by evaluating the land suitability and the farmers' demand. Capacitating the stakeholders with the knowledge about the environmental controversies and benefits of *Eucalyptus* should be the way forward. The paper concludes that *Eucalyptus* like any other tree species should be managed with the right silviculture: planted in the right site and tended properly to optimize its positive values and reduce possible negative effects.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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