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Review

Is the expansion of *Eucalyptus* tree a curse or an opportunity? Implications from a dispute on the tree's ecological and economic impact in Ethiopia: A review

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This review was made to bring forth the contradicting outlooks from different research findings, challenges on the Eucalyptus species and show the opportunities we have with the tree. Due to the impact of Eucalyptus tree species on ecological health and agricultural productivity, ecologists, policy makers and politicians have had a negative view on this tree species. Hence, attempts are made to remove the tree from the agricultural landscape in some part of Ethiopia. In contrast, the farmers of Ethiopia prefer the fast growing, economically attractive, and the quality wood yields of Eucalyptus tree species. So we need to look for other dimension to coincide the existing contradictions. Eradication of the tree cannot be solution without replacing with suitable tree species for maintaining biodiversity and ecological balance. The tree can continue to supply fuel wood and construction material and thereby retard the rate of deforestation and loss of biodiversity resources of the remnant forests of the country. Collaborative work is crucial to gear efforts towards the establishment of a proper management system for the cultivation of Eucalyptus tree. Appropriate management practices such as species selection, planting site selection, correct site-species matching and efficient utilization can maximize the opportunity obtained from the tree. It is also very important to look for alternative trees species to replace Eucalyptus trees, and further studies are required to test the level of Eucalyptus species impact on specific ecosystem. Also, polices need to achieve a reasonable trade-off between the socio-economic value and agro-ecological conservation.

Key words: Agro biodiversity, biodiversity, ecology, eucalyptus, forest.

INTRODUCTION

Eucalyptus species are the most widely introduced long and ever green exotic trees from Myrtaceae family (Rassaeifar et al., 2013). Eucalyptus was introduced to Ethiopia as modern tree plantation from Australia in 1895 during the time of Emperor Menelik II to alleviate shortage of firewood and construction wood in the capital,

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Addis Ababa (Amare, 2010; Yitebitu, 2010). Today, Eucalyptus is the characteristic feature of the rural landscape and it is very important in smallholder livelihood in most parts of Ethiopia. It covers higher share of fuel wood and construction materials supply compared to other forest resources in Ethiopia (Mekonnen et al., 2007).

Currently, more than 100 species of *Eucalyptus* are grown in Africa, and about 55 of them are cultivated in Ethiopia (Friis, 1995). Ethiopia holds the largest Eucalyptus plantation in East Africa and it produces the most important commercial species: *Eucalyptus globulus* locally known as *Nech-Baharzaf* and *Eucalyptus camaldulensis* locally known as *Key-Baharzaf*. However, *Eucalyptus grandis, Eucalyptus saligna, Eucalyptus veminalis, Eucalyptus citiodora,* and *Eucalyptus bicostata* are also wide spread popular species in the country (FAO, 2009).

The problems of *Eucalyptus* tree planation cited are mostly related to its effects on the environment. In FAO (1988) and Anonymous (1992), the adverse effects of Eucalyptus tree species on the soil are related to the leaf litter on soil humus, and failure to control or sometimes to aggravate soil erosion. In addition, it is mentioned that the tree inhibits the growth of other vegetation under their canopy and refrains food supplies or adequate habitat for wildlife (Cordero–Rivera et al., 2017).

However, the success of this species in Ethiopia landscapes is not without limitations. The increasing interest of smallholder farmers to cultivate *Eucalyptus* species in a monoculture stand complicates systematic *Eucalyptus* management to minimize environmental impact and insure sustainable land use system (FAO, 2009). This conflicting interest between short term benefit from *Eucalyptus* plantation by farmers and long term benefits from conserving biodiversity and the environment needs wise decision. Therefore, this review was made to synthesize literatures on the impact of *Eucalyptus* tree plantation on the ecosystem and the environment, and on the high interest of farmers towards this tree species. Then, this review forwards ways of reconciling the existing views, recommends the opportunities we have of *Eucalyptus* species and raises research gaps.

Rationale of the review

This review is framed to have in-depth look on existing literatures and personal observations regarding the controversial responses of people towards the impact of *Eucalyptus* tree species on socioeconomic, biodiversity and sustainable food production system. Major emphasis is given to portray the need of balanced judgment towards the *Eucalyptus* tree species. Besides, the future site specific research gaps were indicated to fill the technical and attitudinal gaps. The review is based on information published in journal articles since 1993, M.Sc. thesis and PhD dissertation papers, proceedings, recent reports from libraries and other relevant information including personal observations.

EXPANSION OF *EUCALYPTUS* PLANTATIONS IN ETHIOPIA

In Ethiopia due to the population pressure and unwise resource utilization, forest lands and marginal lands are converted to cultivation and fast growing trees plantation like *Eucalyptus* species. For this reason, the replacement of well-adapted, nutrient additive indigenous trees by *Eucalyptus* tree plantations is becoming a common practice (Jouquet et al., 2007). This is on the other hand reasoned out that the expansion of fast growing native and exotic tree species plantation is with the intention of delivering the current market demand of quality timber and other wood products in Ethiopia (Laclau, 2003; Lemma, 2006). The natural forests in Munesa Shashemane, Ethiopia was converted into agricultural land for crop cultivation, and later on the same land was converted to *E. saligna* and *Cupresus lusitanica* tree plantations when the land productivity got low (Lemenih et al., 2004). Apart from this, there are several examples in southern part of Ethiopia where *Eucalyptus* has expanded at the expense of natural forests, agro-biodiversity in the cultivated lands, and grazing lands (personal observation). The land use land cover classification with the use of landsat4 TM image has shown that exotic tree plantation mainly *Eucalyptus* has spatially increased with time next to cultivated land use while the forest, shrub lands, wetlands, and grass land cover was shrinking from 1984 up to 2010 in Wallecha Watershed, Southern Ethiopia (Babiso et al., 2016).

Eucalyptus is one of the most important planted tree species in Ethiopia, covering about 506,000 ha (FAO, 2009). Out of 133,041 ha of community tree plantations in Ethiopia between 1978 and 1989, *Eucalyptus* species comprise 58% (Yitebitu et al., 2010). Nearly all of the reports on *Eucalyptus* tree species indicate that the rate of expansion of *Eucalyptus* is accelerated by a quality and amount of goods it provides per a given land use time, and economic importance of this species compared to other tree species (FAO, 2011).

The farmers noticed the negative influence of *Eucalyptus* on neighboring food crops from the low performance for crops which might be due to the competition of soil moisture and nutrients, and shade effect of the tree in Amhara region, Ethiopia (Alebachew et al., 2015). Despite farmers recognition of adverse effects of *Eucalyptus* tree on the ecosystem; the *Eucalyptus* plantations are expanding at the expense of biodiversity of the forest and the agricultural lands from time to time in Ethiopia. This is mainly influenced by the economic benefits, ease of cultivation and high

productivity of the tree (Mekonnen et al., 2007; FAO, 2009; Bekele, 2015). The expansion of *Eucalyptus* tree species can also be attributed to the rapidly changing global market for products from the tree and the interest of wide-scale planting for the production of biofuels (Richardson and Rejmanek, 2011).

THE IMPACT OF *EUCALYPTUS* TREE SPECIES

Water resources

Farmers in the Ethiopian highlands perceive that *Eucalyptus* plantation have affected the flow rate and even dried up springs when planted around them. *Eucalyptus* tree species lowers the ground water table as a result of a high rate of evapotranspiration it has; and aggravates desertification (FAO, 2009). *E. grandis* takes up, almost twice as much water as *Pinus patula* does during the first decade after planting (Dye and Bosch, 2000). The rate of water uptake by the *Eucalyptus* plantation is expected to be high at the young age due to its fast growth habit. At the peak of the dry season, *Eucalyptus* transpires 4-5 times more than *Podocarpus* and *Cupressus* trees of similar size (Fetene and Beck, 2004). *Eucalyptus* has three times fine root biomass in the surface soil compared to mixed plantations; which indicates that planting herbaceous crops in association and adjacent to *Eucalyptus* may lead to water competition stress on crops (Gindaba, 2003). In heavily waterlogged areas and flood plains, *Eucalyptus* trees have commonly been planted to drain water, which could otherwise harbor mosquitoes (FAO, 2009).

Allison and Hughes (1983) have found a change in the ground water recharge after the clearing of *Eucalyptus* tree in semi-arid region of Southern Australia. In their study, the recharge rate beneath native *Eucalyptus* species was <0.1 mm/year, but the recharge increased to 5 and 30 mm/yr following the clearing of the *Eucalyptus* species. There is evidence that *Eucalyptus* trees competes for water with agricultural crops lowering agricultural output as far as 10 m away from where trees are planted (Jagger and Pender, 2000). This may indicate that *Eucalyptus* trees if planted in drought prone regions can cause depletion of soil water and water sources. This impact is often manifested in terms of its canopy interception, runoff regulation, water uptake, and soil moisture depletion (FAO, 2009). This hydroulogic behavior of *Eucalyptus* is the same for Ethiopia. Although the impacts of *Eucalyptus* such as depletion of water table and the effect on hydrological cycle remain uncertain, they are still the agenda of arguments.

Nutrient resources

Eucalyptus trees have been shown to deplete soil nutrients when it was integrated in agroforestry system (Jagger and Pender, 2000), and this characteristics is believed to aggravate the stress of competition when the trees are planted adjacent to agricultural crops. Chanie (2009) found out that there was a 10 fold difference in biomass of maize between the 1 and 20 m distance from *Eucalyptus* tree bole. The nearer the crops to the *Eucalyptus* canopy were, the lower were the crop yield and biomass production, and the impact of *Eucalyptus* was higher as compared with *Croton macrostachyus* trees in the farmlands (Chanie, 2009). Another similar study by Alebachew et al. (2015) showed that with distance from the tree stand (2 to 20 m), plant height of maize, biomass, and plant count were increased as compared to the control in Amhara region, Ethiopia. This may indicate the influence of the tree on the yield and yield components of maize which could be associated with soil nutrient depletion close to the unmanaged *Eucalyptus* trees plantations.

Jagger and Pender (2000) questioned the potential of *Eucalyptus* trees to increase soil organic matter stocks and found the potential to recycle soil nutrients is very weak. In the experiment made to compare the soil organic matter (SOM) under the tree canopy, the trees have not changed the soil organic matter compared with outside the canopy soil (Chanie, 2009). Considering long term land use effects in Munesa Shashamane, Ethiopia, *E. saligna* was indicated to be less preferable plantation species for soil fertility restoration as compared with *Cupresus lusitanica* tree species (Bajigo, 2017). Moreover, due to the fast growth and short rotation time, there is high chance of mining the soil nutrient by *Eucalyptus* tree plantation stand. In contrast to other commonly used afforestation and agroforestry species such as *Leucaena spp.* and *Acacia spp.*, *Eucalyptus* species do not fix nitrogen and less likely restore the land with essential elements sustainably (Jagger and Pender, 2000). The yield of wood product is higher from *Eucalyptus and* therefore expected to have taken more nutrient too (Bajigo, 2017). Various soil physical quality indicators and some soil chemical properties, mainly organic carbon, and total N, P and K decreased as a result of reforestation with *Eucalyptus tereticornis* plantations and further decreased with increasing age of the plantations in the central Himalay (FAO, 2011). Despite of the aforementioned negative connotations with Eucalyptus plantations, however forest management such as litter management and frequency of harvesting can affect the SOM. Afforestation with *E. grandis* for 20 years returned the total SOC to nearly the native forest level after consecutive 35 years of pasture and 20 years of agriculture (Lemma et al., 2006).

Allelopathic effect on other species

Despite the benefits the *Eucalyptus* trees provide, some

adverse reactions against planting of this tree is taking place; however, based on different aspects of technical, ecological and socio-economic arguments, the reactions on planting *Eucalyptus* spp vary (Teketay, 2000a). One of the ecological arguments is that eucalypts has allelopathic effect on other species close to or under the *Eucalyptus* and therefore threaten biodiversity and habitat quality (El-Darier, 2002; Watson, 2004). In the highlands of Ethiopia, farmers relate hampering effect of *Eucalyptus* trees on the growth of other understory or adjacent intercropped crops to competition for water and nutrient rather than allelopathic effects (FAO, 2009). *Eucalyptus* species allelo chemicals have caused understory suppression especially in drier climates (May and Ash, 1990). However, the crop yield reduction is the major influence that *Eucalyptus* has when crops are present under or adjacent to it. The leaf litter of *Eucalyptus camaldulensis* has shown inhibitory effect on nodulation of test plants in laboratory experiment although the trend of effect was increasing with the increase of leaf litter (Ahmed et al., 2008). It has been hypothesized that long term exposure to allelopathic chemicals may result in a bare soil and thereby to a risk of soil erosion, which may have implications for sustainable land use over time (Jagger and Pender, 2000).

Fikreyesus (2011) showed in a laboratory studies that *Eucalyptus camandulensis* has allelopathic potential from its inhibitory effect on agricultural crops in the absence of fungi and bacteria. In both laboratory and greenhouse experiment, the effect of essential oil extracted from the leaves of *Eucalyptus globulus* against two weeds indicated a decrease in the germination percent and other growth parameters (Rassaeifar et al., 2013). This may depict that *Eucalyptus* essential oils could possess inhibitory potential against crops. The study to understand the allelopathic effect of the leaf extracts of *Eucalyptus globulus* on eggplant showed the reduction of eggplant growth parameters such as root and shoot lengths, and fresh and dry weights with increasing concentration of the leaf extract (Dejam et al., 2014). The mechanisms of inhibition of crop growth were not clearly known; hence, different field and laboratory experiments may strengthen the justification that *Eucalyptus* trees have inhibitory chemicals that can affect the other plants in its vicinity. However, the techniques employed in many studies do not mimic the natural ecological processes, and there is still a need to further experiment to partition and understand the level of allopathic effects of different *Eucalyptus* spp.

Agro biodiversity and human nutrition security

There is a global growing consensus that business as usual approach is not working for sustainable nutrient dense food production system. Rather, a paradigm shift, conserving the natural form and quality of land scape is critical (GPAFSN, 2016; IPES, 2016). As stated in the International Panel of Experts on Sustainable Food Systems (IPES) 2016 report, a fundamentally different model of agriculture based on diversifying farms and farming landscapes is required for sustainable food system to satisfy the ever blooming food demand in terms of quantity, and nutritional value. The 2030 Agenda and its Sustainable Development Goals provides a framework that includes nutrition goals in farming systems; increasing yields without increasing the levels of inorganic and synthetic chemicals in the system; shaping landscapes and improving environmental integrity (Bioversity International, 2017). In this case it gives emphasis to agro-biodiversity that also includes agroforestry (Lundgren and Raintree, 1982). Beyond ecological services, agro biodiversity insures more sustainable and productive land scape and sustainable food production system (FAO, 2017).

Maintaining the landscape for agro-biodiversity is far better contributing to sustainable food system than converting it to monoculture tree plantation such as *Eucalyptus* tree species. Beyond its antagonistic characteristics to other plants monoculture plantations of *Eucalyptus* species simplifies the ecosystem ecologically and economically that meaningfully affects its ecosystem function. For instance, fast growing *Eucalyptus* tree plantations affected hydric resources which in turn lead to diminish macro-invertebrate richness and diversity (Cordero–Rivera, 2017). This kind of practices posing environmental impact and compromises the food production system through threatening the agro-biodiversity. In Wolaita, southern Ethiopia, *Eucalyptus* trees are planted as boundary demarcations, home gardens, woodlots and as roadside plants (Alemu, 2016) in the expense of loss of agro-biodiversity. The current land use changes favors the expansion of *Eucalyptus* tree woodlot while exacerbating agricultural biodiversity loss (Bajigo and Tadesse, 2015).

There are ample research evidences to show the negative impact of *Eucalyptus* tree species plantation on the biodiversity of the plantation site, and affects the nutrition security by discriminating a diversified food production (Scott, 2005; Jaleta et al., 2016; Cordero–Rivera, 2017). It is very aggressive characteristics to make *Eucalyptus* not compatible to the diversified stands, mainly the agroforestry systems. On the comparison made, the average undergrowth density of the *Eucalyptus* trees was lower than that of under coffee garden shade in agricultural land set up depicting that *Eucalyptus* with high fine root density competes more for nutrient than understory herbaceous crops (Chanie, 2009). Despite the *Eucalyptus* trees competition and allelopathic effects on the biological diversity in agroecosystem, land conversion to *Eucalyptus* tree plantation is aggravated due to high economic value (Gebrehiwot, 2013). *Eucalyptus* has expanded at the rate

of about 18.82% at the expense of grassland and bush land, and its expansion was mainly due to the socio-economic benefits it provides to the community; as it was one of the few cash earning means in Ethiopia (Jaleta et al., 2016). Hence, farmers in Ethiopia convert the land uses from ecologically and economically diversified agrobiodiversity into monocultural *Eucalyptus* plantation stands, which in turn affects the nutrition security of the community/ecoregion.

SOCIO-ECONOMIC VALUE OF *EUCALYPTUS* PLANTATION

Land use change is a product of socio-economic and environmental factors. Land use change is influenced to a great extent by the performance, priorities and livelihood strategies of the local people, but also influenced by policies and regulations, institutional and cultural factors too (Maitima et al., 2004). Economic returns from crops like khat (*Catha edulis*) and *Eucalyptus* are taken as a main factor for the land use change from diversified and ecologically complex system to mono-cropping system in the Southern Ethiopia (Gebrehiwot, 2013); hence, *Eucalyptus* tree plantation expanded on homegarden agroforestry land use and the trend has been steadily increasing due to household financial income attraction from the tree crop. Consequently, the diversified food production, which is expected from homegarden agroforestry, and associated livestock products were declining (Gebrehiwot, 2013).

In the study undertaken in central Ethiopia, the result show that the majority of farmers, urban dwellers, and experts of the district agricultural office; about half of government extension agents; and some researchers preferred planting *Eucalyptus* tree species on agricultural landscape (Mekonnen et al., 2007). This finding also indicated major factors for the preference of planting *Eucalyptus* were the increasing demand for wood products in the market; ease of cultivation, wider adaptability and high rate of biomass production of the tree; and the decline in land productivity for agricultural uses. Chanie (2009) has shown that *Eucalyptus* tree planting is the most dominant tree plantation practice in the Koga Watershed in north western Ethiopia for fuel wood production, income generation and construction material demand that may not be adequately supplied with indigenous species. In south central Ethiopia, all of the construction, 20% of the charcoal, 93% of other wood products come from the *Eucalyptus* (FAO, 2011). In Lake Tana plain, *Eucalyptus* tree planting was intended for fuel wood (100%), income generation (96%) and construction (84%) despite the tree was not preferred for environmental conservation (Chanie et al., 2013).

It has been found out that the income generated from *Eucalyptus* is by far higher than the income generated from cereal crops, although the largest proportion of land was allocated for agricultural activities (Bekele, 2015; Jaleta et al., 2016). The study in central highlands has shown that *Eucalyptus* contributed about half of household income when compared with cereal crops (Kebebew and Ayele, 2010). Several studies in Ethiopia (Senbeta and Teketay, 2001; Lemenih and Teketay, 2004; Bekele, 2015) reported a positive economic role of *Eucalyptus* tree. *Eucalyptus* tree has determined the rural households' income generation practices even under moisture stressed seasons and maintained the food security status of the households through the tree products sale (Alemu, 2016). *Eucalyptus* is the tree of choice for wood production and economic benefit by farmers in Ethiopia regardless of the claims that indicate the tree is harmful to the environment and biodiversity (Chanie et al., 2013).

ECOLOGICAL ROLES OF *EUCALYPTUS* TREE PLANTATION

The 2% actual deforestation rate in Ethiopia was reported by WBISPP (2005); however, the tree is over utilized for various kinds of wood and non-wood based forest products; fuel wood consumption is significantly high in Ethiopia. The national energy balance is dominated by fuel wood, which is accounting for over 90% of the primary total energy supply (Yitebitu et al., 2010). While the main source of fuel wood is natural forest, the eucalyptus plantation shares the burden and lets the natural forest protected of deforestation Table 1.

However, *Eucalyptus* plantation has positive contribution in light of meeting the increasing demand of fuel-wood and construction materials. Since *Eucalyptus* tree species are fast growing and providing quality wood in small woodlots for the population that meets their demand, the tree species reduce the destruction and degradation of indigenous species of natural forests. The tree therefore indirectly serves to protect the biodiversity away from the planted site by preventing the destruction of natural forests (Kenya Forest Service, 2009). In line with this, several studies have confirmed that the introduction of *Eucalyptus* species to Ethiopia was a great success in perpetuating the indigenous species, which implies that this tree is playing a positive ecological role (Senbeta and Teketay, 2001; Lemenih and Teketay, 2004; Bekele, 2015).

One of the criticisms associated with *Eucalyptus* elsewhere is that it prohibits the establishment of understory plant species due to the fact that the tree is usually taller than other plants of equal age, so that shade over the understory species. Besides, the annual crops grown close to *Eucalyptus* plantation yield less than those grown far from the edge (Chanie, 2009). This may show the lack of sound management besides the effect of the tree species (Teketay, 2000b). Despite of these facts, *Eucalyptus* tree species expansion by itself is

Table 1. Status of fuel wood demand in Ethiopia.

Source	Annual wood supply	Annual consumption	Deficit or surplus
World Bank (1984)	8.1 MT (13.5 million m^3)	20.34 MT (33.9 million m^3)	Consumption is 2.5 annual yield
ENEC/CESEN (1986)	63 MT	24 MT (40 million m^3)	Positive balance
EFAP (1994)	8.6 MT (14.4 million m^3)	35 MT (58.4 million m^3)	Consumption 4 times higher
UNDP/World (1996)	n.a.	31.5 MT (52. million m^3)	Deficit indicated
WBISPP (2005)	50.1 MT (84.9 million m^3)	53.6 MT (89.4 million m^3)	Deficit of 3.5 MT
EFAP (1994) projection for 2020	-	-	Deficit 87-121 million m^3

Source: Yitebitu et al. (2010).

not hazardous to the ecosystem when a proper management and species selection is in place. Rather, if possible to overcome the limiting factors with *Eucalyptus* species, it can improve the efficiency of the land performance (Aramde and Hailu, 2013). As intercropping of rice and beans with *Eucalyptus camaldulensis*, and *Eucalyptus urophylla*) show good yield in Brazil (Ceccon, 2005; Ceccon, 2007), *Eucalyptus* based agroforestry system in the waterlogged highlands of Ethiopia has shown a rise in the productivity without an effect on the soil nutrients (Kidanu, 2004).

Not all *Eucalyptus* tree species have a detrimental shading effect on the growth of understory plants (Yirdaw and Luukkanen, 2003); rather, some evidences show a positive relation to biodiversity. For instance, the older *Eucalyptus* tree plantations exhibited a significantly larger proportion of woody plants richness in its understory although a lower richness of herbaceous species in this age class in China (Jianping et al., 2015). In the same context, *Eucalyptus globulus* and *E. saligna* plantations established near to seed sources from nearby natural forest have fostered the regeneration of native woody species (Senbeta et al., 2002). Similar finding was reported by Telila et al. (2015) that the small *Eucalyptus* plantations have a potential to foster native woody plant diversity in central Ethiopia. Despite the reality that the herbaceous species richness is low under *Eucalyptus* tree shade, Teketay (2000a) has found greater richness of herbaceous plant species under *Eucalyptus* than adjacent natural forest. On a heavy clay soils, wheat production was not affected by *Eucalyptus* tree (Kidanu et al., 2005). Furthermore, when *Eucalyptus* tree was used as coffee shade, it was found that the coffee quality was as acceptable as that from indigenous forest coffee (Alem and Woldemariam, 2010). The implication is that *Eucalyptus* tree species selection, matching to the agro-ecology, silvicultural management, and appropriate land use planning would help to utilize the potential of *Eucalyptus* tree species in an ecologically harmonious manner.

Growing the *Eucalyptus* tree can serve as a source of shade, erosion control, windbreak and shelterbelt roles of the tree in farmlands and can moderate the climatic factors (temperature and rainfall extremes) (Alemu, 2016). The experiment of Jaleta (2017) in central highlands of Ethiopia shows that the moisture content under Eucalyptus woodlot was significantly higher than cultivated land, while there was no significant difference when compared to the grassland as indicated in Table 2. Hence, the experiment revealed that the expansion of Eucalyptus has no significant impact on surface runoff generation if it is expanded on previous grassland; rather it could significantly reduce the surface runoff generated if it is planted on previously cultivated land.

Due to its fast growth rate and high biomass accumulation, *Eucalyptus* can play very important role in carbon sequestration, and may be the most preferable plantation tree species to combat global warming (Lemma et al., 2006).

CONCLUSION

The existing knowledge and practices indicates that there are opposing views on the *Eucalyptus* tree species depending on the view point they consider. With some empirical evidences on the *Eucalyptus* tree species impact on soil quality, biodiversity, agricultural productivity, and the hydraulic system, numerous ecologists have shown a negative view on the tree. With the conviction of the evidences, policy makers and politicians have also expressed their negative attitude towards this tree species. These groups forecast the long term detrimental impact of *Eucalyptus* tree on ecosystem of the landscape which integrates the tree. Land use system must lean towards maximization of the overall land economic value in a sustainable manner. In contrast, farmers who plant *Eucalyptus* and benefit from it desire the fast growing, economically attractive, and the quality wood yielding *Eucalyptus* tree species without regarding the environment. On the other hand, the meaningful contribution of this fast growing tree in safeguarding the remnant, and newly developing natural forest is very crucial through fulfilling the wood demand of the country. Despite the existing evidences on *Eucalyptus* tree plantation's negative ecological impact, eradication of the tree cannot be solution. Rather, it is better to gear efforts towards the establishment of a proper management

Table 2. Mean of rainfall, runoff and runoff coefficient from three Land use land cover.

Land use	Daily rainfall (mm)	Daily runoff (mm)	Runoff coefficient (%)	Total runoff (mm)
Cultivated land	11.8 ± 0.53	(2.53 ± 0.08)[a]	(23.92 ± 0.33)[a]	(191.9 ± 4.2)[a]
Grassland	11.8 ± 0.53	(1.95 ± 0.07)[b]	(17.90 ± 0.25)[b]	(147.8 ± 4.5)[b]
Eucalyptus woodlot	11.8 ± 0.53	(2.03 ± 0.07)[b]	(18.92 ± 0.25)[b]	(154.0 ± 2.9)[b]
LSD (5%)	-	0.19	0.77	5.57

Source: Jaleta et al. (2017).

system for the growth and development of the *Eucalyptus* tree plantations in agricultural landscape, and large plantation stands. For instance, thinning reduced stem density by two-thirds, and substantially raised the activity and richness of bats, and bats species composition (Gonsalves et al., 2018). The *Eucalyptus* trees can continue to combat the growing deforestation rate and loss of biodiversity due to deforestation by reversing the fear of ecologists and other concerned bodies regarding ecological deterioration. Appropriate management practices such as species selection, planting site selection, and correct site-species matching efficient utilization can be sustained with little adverse impact on the ecology of agricultural landscape. Despite of this, contradictions may persist until alternative trees that replace *Eucalyptus* trees with equivalent socioeconomic value while bringing positive ecological function is found. It seems not possible to totally refuse and eradicate the tree, particularly from Ethiopia and developing countries in general, whose current dependency on *Eucalyptus* is enormous. Rather, more researches are required to test the level of *Eucalyptus* species' specific impact on ecosystem while fulfilling all the interest of the land users at all level. Therefore, wise utilization of the potential of *Eucalyptus* tree on the areas having large land size holdings with well-designed integration to other land uses can solve the current aggressive deforestation and forest degradation from the increasing wood product demand.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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