



Effects of eucalyptus plantation on Environment and water resource

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Abstract

The word eucalyptus refers to the well-hidden characteristic of its flower and fruit that protects its inner section. The evergreen species varies from shrub and multi-stemmed tree less than ten meters to single-stemmed tree more than sixty meters tall. This review paper aims to provide a better understanding of the effects of eucalyptus plantation on Environment and water resource. Outside its native habitat, eucalyptus was first grown in Portugal some four hundred years ago. Subsequently, the species became widely distributed in Europe, Latin America, Asia and Africa. It generates substantial income to rural households. Eucalyptus has its own positive and negative effects on ecological condition. There is limited evidence regarding the impacts of Eucalyptus on water. Certain trees that are integrated into agricultural systems can increase the efficiency of water use, while plantations of fast-growing trees like Eucalyptus trees can exacerbate the problem of water shortages. Eucalyptus as controversial species which indicates that the controversies of the species are continuing among the economist and the environmentalists. It is true that it may not have an equivalent impact on environment as compared to natural forest and indigenous tree species, but as compared to other commonly used plantation tree species and some agricultural crops specifically it is found to be more efficient in many environmental aspects.

Keywords: Environmental protection, Ecological effect, Ethiopia, Eucalyptus Species

Introduction

Eucalyptus is one of the diverse genus of flowering plants in the world. It belongs to the family Myrtaceae, subfamily Myrtoidae and consists of some eight hundred species. It is native to Australia and Tasmania with a small number of species also found in New Guinea, the

Philippines and Indonesia. It was the French botanist Jacques-Julien Houton from Labillardière that classified and named the species Eucalyptus globulus Labill in 1799. The word eucalyptus is derived from the Greek 'eu' and 'kalyptos' which means hidden. Hence, it refers to the well-hidden characteristic of its flower and fruit that protects its inner section. The evergreen species varies

from shrub and multi-stemmed tree less than ten meters to single-stemmed tree more than sixty meters tall. In most cases it grows at altitude that ranges from sea level to 1,850 m above sea level but extends beyond that in Ethiopia (Abebe and Tadesse, 2014).

The major Eucalyptus growing countries are: China (170 million ha); India (2.5 million ha); and Brazil (3.7 million ha) (Liu and Li, 2010). In Africa, South Africa has the largest area under Eucalyptus plantations of about half a million hectares (Teketay, 2003). In Ethiopia, the genus was introduced during the regime of Emperor Menilek (1868-1907) in 1894/95 (Alebachew et al., 2015). The purpose was to supply fuel wood and construction timber to the new and growing capital city, Addis Ababa. Species of the genus Eucalyptus (common name Eucalyptus) are widely planted all across Ethiopia including on large areas of land previously allocated to food production (Liang et al., 2016). In recent decades Eucalyptus has also increasingly been planted on lands around and within “church forests,” sacred groves of old-aged Afromontane trees surrounding Ethiopian Orthodox Tewahido churches. These revered holy sites have long been recognized for their cultural values and also for their ecosystem services including their potential to support species conservation and restoration, as church forests are some of the only remaining sanctuaries for many of Ethiopia’s indigenous and endemic plant and animal populations (Liang et al., 2016). Currently, it is estimated that, over 500000ha of the land is covered by Eucalyptus plantation in Ethiopia (Abebe and Tadesse, 2014). This review paper therefore, aims to provide a better understanding of the effects of eucalyptus plantation on Environment and water resource.

Global distribution

According to Abebe and Tadesse, (2014) outside its native habitat, eucalyptus was first grown in Portugal some four hundred years ago. Subsequently, the species became widely distributed in Europe, Latin America, Asia and Africa. Prominent among some of the countries are California, Ecuador, Colombia, Chile, China, Spain, Israel, Ethiopia, Morocco, South Africa

and Uganda in all, over ten million hectares of eucalypt are found in the tropics at the end of 1990 (Roberts,1988). In one way or another, these countries have benefited from eucalyptus as fuel wood, charcoal, poles, posts, source of essential oils etc. It has also been the basis for several industries as timber, paper and pulp manufacture. The tree equally provides honey flora, shade, and wind-break.

Eucalyptus distribution in Ethiopia

Eucalyptus expansion, it offered multi-purpose use especially as a fuel wood due to its efficient conversion of solar energy into biomass of high calorific value. It was thus designated ‘Bahir Zaf’ which in Amharic means the ‘tree from beyond the sea’ and is reflective of its overseas origin. Accordingly, the ‘red’ eucalyptus, *Eucalyptus camaldulensis* and the ‘white’ eucalyptus, *Eucalyptus globules*, were designated as “Qaybaharzaf” and “nechbaharzaf”, respectively (Abebe and Tadesse, 2014).

Even though, it is difficult to determine the exact area of eucalyptuse in Ethiopia, there are two area estimates which were reported by Demle (2002) and Amare (2002) of 477000ha and 506000ha respectively.

Given its relative ease of establishment with tolerance to wide environmental conditions, including pests and diseases, eucalyptus radiated into rural landscape from its first node, Addis Ababa. At present, it has spread to urban and peri-urban canters, woodlots, homesteads, communal lands, schools, churches and monasteries (Wassieet al., 2005). As a result of its versatile use and substantial economic benefit, it has become an important primary species that has improved livelihood. In places it seems to override crop production and this has made it one of the highly valued tree species in the country. Lots of farmers have also converted their farms to eucalypt and diversified their income (Kidanu et al., 2005). As a consequence, it has become part of the farming system in certain areas. Where there are few trees to protect the soil, eucalyptus has acted as a biological conservation measure.

This is despite its discouragement by some due to environmental concerns.

Socio economic impact of eucalyptus in Ethiopia

Eucalyptus has several desirable socio-economic benefits including financial, employment and security. The study of Mekonnen et al. (2007) in central Ethiopia, reported that the major factors driving farmers to plant eucalyptus are: increasing demand for wood products in the market, the unavailability of wood on farm, its high rate of biomass production, its ease of cultivation and wider adaptability, its non-palatability to livestock, the decline in land productivity for agricultural use, the decline in off-farm employment opportunities.

Eucalyptus generates substantial income to rural households. In central Ethiopia eucalyptus generated a quarter of annual cash incomes (Mekonnen et al 2007). The same study showed that 74 percent of firewood sold was eucalyptus. Importantly, eucalyptus yields better income than other exotic trees, even better than some agricultural crops (Amare, 2002).

According to various studies explained that eucalyptus provided employment for thousands of unskilled labourers. In addition to employment, it provides community development support such as building residences, roads, schools, and health posts and flour mills.

Another important contribution of this tree is security. Eucalyptus stands proved to be an important guarantor for farmers who want to maintain the ownership of their rural land while living in urban areas (Amare, 2002). Growers, by planting eucalyptus, secure ownership of the land and at the same time keep the land productive while they are away. On top of this, the amount of eucalyptus trees indicates the level of affluence of the growers. In Rwanda, banks accept eucalyptus stands as collateral to lend money. This tree species is important in the construction industry of East Africa. The poles of eucalyptus are used

for scaffolding in the constructions of high-rise buildings, bridges, dams, and roads.

As scientific studies indicated that, on developing countries offers conflicting results on the role of cash cropping on food security and poverty alleviation (Hirons et al., 2018; Kuma et al., 2018). Eucalyptus plantations could be considered as alternative source of income, allowing improvement in the small farmers' food security through food purchase, or as an additional source of income ((Kebebew, 2010). Other studies showed that smallholders tend plant cash crops mainly when the expected profitability is higher than the propensity to cultivate cash crops smallholders tend to plant cash crops mainly when the expected profitability is higher than the economic return from other crops (Lukanu et al., 2009; Lukanu et al., 2010). The inclination to cultivate cash crops depends on their return from commercialization and on the farmers' characteristics (Radchenko et al., 2018).

In general, the eucalypts have been planted for various socio-economic purposes in African countries such as Ethiopia, Ivory Coast, Kenya, South Africa, Sudan, Tanzania, Uganda, and Zimbabwe, as well as in India and Pakistan, Brazil, Ecuador, Paraguay and many other countries in South America, Israel and other Middle Eastern countries as well as in its native Australia. The economic returns from a wide range of Eucalyptus products are good: it is used for fuelwood, poles, construction materials, pulp wood, timber, raw material for many industrial uses, oil and medicine, tannin, for fibre and particle board, for honey production, for livelihood support and for employment among many other benefits (FAO, 2006).

Social and economic problems have arisen from insensitive plantation establishment or unwise management, but many of those accounts that have been highlighted in the literature appear to be exaggerated and to ignore the benefits of the genus. In most developing countries in the tropics and sub-tropics, the clearance of trees for agriculture on marginal lands and for meeting

firewood needs has caused environmental degradation made worse by lack of a national land use policy. Eucalypts offer the chance to ameliorate the situation if properly managed and implemented and in fact, the potential contribution of the genus has remained largely unexplored.

According to study of Dessie and Erkossa (2011) Ethiopian farmers who have been interviewed stated that they preferred to plant Eucalyptus: 1) For use at household level (construction, firewood, farm implements); 2) To sell; 3) For soil conservation and gully stabilization; 4) To drain marshy land, which could harbour malaria; 5) To ensure land tenure security.

The study of Mekonnen et al (2007) in central Ethiopia reported that the major factors driving farmers to plant eucalypts were: increasing demand for wood products; the unavailability of wood; their high rate of biomass production; ease of cultivation and adaptability; non-palatability to livestock; the decline in agricultural land productivity; and the decline in off-farm employment opportunities. The same study showed that Eucalyptus generated substantial income for rural households while in central Ethiopia Eucalyptus generated a quarter of annual cash incomes and seventy four percent of firewood sold. Importantly, Eucalyptus yields better income than other exotic trees and even better than some agricultural crops (Amare, 2003). Eucalyptus plantation projects have provided employment for thousands of unskilled labourers and in addition such projects have provided money for community development support such as roads, schools, health posts and flour mills.

Another important contribution of this tree has been security of tenure. Eucalyptus stands proved to be important guarantors for farmers who wanted to maintain the ownership of their rural land while living in urban areas (Amare 2003). Growers, by planting eucalypts, secured ownership of the land and at the same time kept the land productive while they were away. In addition, in Rwanda, banks have accepted

eucalypt stands as collateral for loans. The genus has been very important in the construction industry of East Africa. The poles are used for scaffolding in the construction of high-rise buildings, bridges, dams, and roads.

Ecological effect of eucalyptus

According to Jagger and Pender (2000) Eucalyptus has its own positive and negative effects on ecological condition of the area. Some of the Positive effect of eucalyptus are; best short-term options for the provision of critically required biomass, net soil nutrient contribution through leaf litter on degraded hillsides and waste lands, good potential for topsoil retention on degraded hillside, ability to take up large quantities of water may reduce runoff, flooding and water logging, tree cover may reduce erosion and gully formation, resistant to insects and livestock (Jagger and Pender, 2000).

Eucalyptus has lots of negative ecological effect, some of them; Land scarcity may be a constraint to wide-scale tree planting, deplete soil nutrients needed by agricultural crops, provide organic matter is questionable, Allelo-chemicals negatively influence agricultural production, may complete water away from agricultural crops decreasing agricultural output as far as 10 meters away from where trees are planted, Wide scale hydrological impacts are uncertain, Non-palatability of leaves to livestock (Jagger and Pender, 2000).

Impacts of Eucalyptus on Water Resource

There is limited evidence regarding the impacts of Eucalyptus on water. Water scarcity is an increasingly severe problem across the developing world, with many countries in East Africa already experiencing severe water scarcity (Jagger and Pender, 2000). Certain trees that are integrated into agricultural systems can increase the efficiency of water use, while plantations of fast-growing trees like Eucalyptus trees can exacerbate the problem of water shortages. It is claimed that Eucalyptus trees absorb more water from the soil than any other tree species. The

results of research on the water use and water balance effects of trees in Kenya shows that, Eucalyptus consumes more water, especially during its early growing stages compared to pinus species (Dye and Bosch, 2000).

Eucalyptus is a well-known forest species of high water uptake ranging from 50 Lt/d/plant to even 90 Lt/d/plant, depending upon the adequacy of supply (Joshi and Palanisami, 2011). But, it is also reported that, in stress situation, its roots can grow even up to 20-30 feet and extract more water. The leaf area of the Eucalyptus plants is also another important factor affecting the rate of water consumption. The study by Hatton et al. (1998) concluded that there was a strong linear relationship between tree leaf area and mean daily water use for a wide range of Eucalyptus species grown under similar climatic conditions. Eucalyptus trees also take up a great amount of water from the soil and as a result can affect water availability, competing with crops and other vegetation for water and depleting the water table (Jagger and Pender, 2003). Their high water requirements and deep root systems can give them a relative advantage over other plants in terms of water usage, which can be particularly damaging if Eucalyptus trees are planted in arid regions (PalMBERG, 2002; Jagger and Pender, 2003).

Ethiopian farmers across the country blaming Eucalyptus plantations. This is due to its effect on the water availability and crop production. This was observed during field visit and other research work across the region like Oromiya (East Wollega and West Shewa), Amhara (Bahirdar) and Tigray (Gergera and AbrehaWeatsbha). For example, farmers in the East Wollega (Diga) and West Shewa (Tulu kosoru) believe that Eucalyptus plantations around agricultural land and water sources significantly affect the flow rate of springs and reduced crop production. Some have witnessed that springs have disappeared due to Eucalyptus plantation. Consequently, the community banned any further plantation around water sources such as ponds and springs (Daba, 2016).

However, in some cases, they are planting around degraded land and roadsides areas for their livelihood benefit. This was observed during the households' survey to East Wollega and West Shewa in Oromia, where farmers plant Eucalyptus around agricultural land, river and roadsides areas for their livelihood benefit. The community in this area explain that once Eucalyptus planted in any environments, it grows very fast as they get access to water throughout the years. Farmers claim that the profits that can be gained from the sale of the annually harvested Eucalyptus can outweigh what could have been obtained from the same plot, if they were to plant other crops (Daba, 2016).

Impacts of Eucalyptus on Soil

The disapprovals of the Eucalyptus are justified but, argue that only some species, mainly the deep-rooted types, drain water resources, and that poor forestry practices, like high planting densities and short crop rotations, are primarily responsible for depletion of the soil's nutrients, increased soil erosion, and suppression of the undergrowth (Dessie and Erkossa. 2011). The impacts of Eucalyptus species on soil health remain hotly debated among scientists and development practitioners (Yitaferu et al., 2013). Fast growing and short rotation tree plantations such as Eucalyptus also use escalated amounts of nutrients from the soil in comparison to slow-growing species (Dessie and Erkossa, 2011). Monoculture forest activities such as Eucalyptus plantations may further affect soil chemical characteristics if the organic litter is continuously raked, prohibiting nutrient recycling (Zewdie, 2008).

Soil quality and composition is a significant indicator of ecosystem health, and thus the impacts of smallholder Eucalyptus planting on agricultural land can have great implications for larger development issues such as food security (Lal, 2007). The potential negative impacts of Eucalyptus plantations on soil quality and other ecosystem services have been intensively studied. Studies conducted across many tropical and sub-tropical regions cite high demand for soil

nutrients as an important drawback to Eucalyptus plantations (Kidanu et al., 2005).

According to FAO, (2009), reports that improper land use and soil management, which often leave the soil with less or no vegetation, are the major causes of soil quality deterioration. However, fast growing tree plantations may also lead to soil quality decline when they are poorly planned and not properly managed. The impact of tree plantations upon soil resources has been very much debated and there is no complete consolidated view, partly due to the fact that the impact is much dependent on variable site and forest conditions (Jagger and Pender, 2000). Numerous research reports were appeared on effects of Eucalyptus on soils in several countries over many years (Lemma, 2006).

High rates of soil nutrient uptake in Eucalyptus spp. are due in part to the combined effect of fast growth and the inability to fix nitrogen (Zegeye, 2010); therefore, in both the short and long-term Eucalyptus plantation establishment has been shown to have harmful effects on soil quality and fertility (Chanie et al., 2013). By degrading soils, Eucalyptus may render land less suitable for future growth of crops and natural forests alike (Palmberg, 2002).

In addition to soil fertility and nutrient content, Eucalyptus has been found to have influences on topsoil retention and soil erosion (Jagger and Pender, 2003). Some studies have concluded that Eucalyptus can worsen soil erosion as an indirect result of frequent disturbance from repeated harvesting (Nyssen et al., 2004).

Conclusion and recommendation

Although, it is believed that Eucalyptus has many more environmental benefits (i.e., ecosystem services, biodiversity conservation, soil and water conservation) the controversies are not resolved yet (Ketsela, 2012). For instance, Jaleta et al., (2016) in his study stated the environmental aspects of Eucalyptus with topics entitled as "Eucalyptus as controversial species" which

indicates that the controversies of the species are continuing among the economist and the environmentalists. In fact, the debate is based on the scientific facts. Likewise, although planting Eucalyptus was one economic rational response to the recent change in the rural economic environments caused by the rapid economic growth in the rural community of the country, the government of Tigray regional state has banned planting Eucalyptus tree due to suspected environmental effects.

In fact, it is true that Eucalyptus may not have an equivalent impact on environment as compared to natural forest and indigenous tree species, but as compared to other commonly used plantation tree species and some agricultural crops specifically it is found to be more efficient in many environmental aspects. In general, the controversies on Eucalyptus can be resolved through selecting and matching site potentials with the species characteristics that planting the species on the degraded land may earn better profit than leaving alone whereas planting on fertile and competitive land for other high value crops may worsen the situation.

Abbreviations

EIAR: Ethiopian Institute of Agricultural Research; **FAO:** Food and Agriculture Organization

Authors' contributions

Mekin Mohammed Yimam has designed and carried out the review. And Mekin Mohammed Yimam has wrote the manuscript. Leta Hailu has contributed to the material collection, Writeup, editing the manuscript and the Whole consult.

Availability of data and materials

Not applicable

Competing interests

The author have no competing interest to declare

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