Eucalyptus in Ethiopia

Risk or Opportunity?

Mesfin Abebe
Wubalem Tadesse

የኢትዮጵያ የግብርና ምርምር ኢንስቲትዩት

Ethiopian Institute of Agricultural Research

Eucalyptus in Ethiopia

Risk or Opportunity?

አ.ግ.ም.ኢ፣ *2006*
Website: http://www.eiar.gov.et
Tel: +251-11-6462633
Fax: +251-11-6461294
P.O.Box: 2003
Addis Ababa, Ethiopia
ISBN: 978-99944-53-91-4

Copyediting and design: **Abebe Kirub**

The Cover: Engraving of *Eucalyptus platypodos Cav.* done in 1797 by the internationally acclaimed Spanish botanist Cavanilles. Source: (28).

Dedicated to

the visionaries that charted the open horizon and introduced eucalyptus and the pioneer foresters that blazed the trail to entrench the species in Ethiopia.

Contents

Preface

It is over a century since eucalyptus was introduced in Ethiopia. Given its adaptation, fast growth and good yield, it has provided feulwood, construction material, scaffold, transmission pole, timber etc. At present, there is ove half million hectare of eucalyptus in the country. In view of this, the species has become a defining feature of some rural landscapes and a number of urban centers. However, the species has aroused controversy from its perceived negative impact on ecology and agriculture. Among these are the inhibition of indigenous species; competition for moisture and nutrients; phytotoxicity; and hostility to wildlife.

The authors acknowledge such perception since it has provoked this work that tries to clarify the seemingly unbridgeable intellectual chasm of the “curse-blessing” debate. In essence, with little technical jargon as possible, the manuscript addresses the myth, reality, risks and opportunities that surround the species. Accordingly, each perpective is treated not as a value-laden manifesto, a flagrant violation of the scientific method, but based on imperical evidence. In the process, several issues that capture reality than improve on it are elaborated. Hopefully, these would help make informed decision to minimizes the drawbacks and maximizes the benefits. But, the ultimate aim is the foreward looking conservation-based sustained management and efficient utilization of the species without adverse impact on ecology or agriculture.

Finally, the authors acknowledge with special thanks the Ethiopian Institute of Agricultural Research (EIAR) for the publication of the modest work as part of its effort in the generation and dissemination of R&D knowledge and technology. We also express deep gratitude to Ato Abebe Kirub, Director of Information and Communications Management, EIAR, for his exemplary love of profession that is manifested in the edition and the final publication of the material true to his people-centered commitment.

Mesfin Abebe
Wubalem Tadesse
January, 2014

The Background

The Setting

Ethiopia has extreme contrasts of topological features. It is reflected by the highest peak of Ras Dashen (Ras Dejen) at 4,620 m asl and the Kobat Sink about 110 m *below* sea level in the Afar (once called the Danakil Depression). The unevenness of the landscape was accentuated through millennia by tectonic movement, volcanic eruption, subsidence, erosion and deposition. This is reflected by high and rugged mountains with precipitous edges, flat-topped plateau, deep gorges dissected by numerous rivers, incised river valleys and rolling plains. Another feature in the country is the Great Rift Valley that runs north to south bisecting the plateau into the western and south-eastern highlands adjoined by the vast semi-arid lowlands. Therefore, the country has distinct agro-ecological zones that have great diversity of climate, vegetation and soils. These have offered a wide spectrum of habitats for a large number of endemic plants and animals.

Within these diverse ecosystems are: landscapes rich in biodiversity to bad lands; nutrient-poor to organic matter-rich fertile soils; lush forests to degraded barren lands; wetlands to semiarid areas etc. Such a setting has defined the limits under which farmers and pastoralists have lived. Theit livelihood

patterns can be catagorized as crop-livestock integrated sedentary agriculture in areas of reliable rainfall; pastoralism and agro-pastoralism in the semi-arid areas; slash and burn shifting cultivation in high rainfall areas; and hunting and gathering where forests abound. Such diverse livelihood is intricately linked to biological diversity.

Accordingly, rural communities have had conjugal bond with nature. They left positive imprint through the conservation of indigenous tree species, introduction and domestication of animals and plants. Other examples are the traditional farm forestry or agroforestry of the south and southwest, soil and water mnagement in Konso, resource conservation and management by pastoralist and agro-pastoralists. On the other hand, the slow onset ecological disruption that has complex root causes was exacerbated by the unplanned human exploitation of natural resources over extended period. Out of necessity, they 'mined' indigenous forests to meet their basic needs for life. This has caused prominent geophysical processe such as deforestation, erosion, siltation, and land degradation at work. As a result, the danger of being steam-rolled by nature when it became antagonistic has increased. In some cases, the conflict from the use of the dwindled finite resources within a fragile ecosystem has caused environmental damage. At times, the outcome has been armed strife with human casualty.

Further, long-drawn feudal armed conflict where past governments burnt forests to subdue a population and imperial wars of conquet had their toll on natural resources deterioration.

The harm inflicted on perceived enemies has also been one major cause of forest destrcution. This has been witnessed wherever there were armed struggle for liberation. It was compounded by forced social reorganization and the unremitting turbulence from unplanned resettlement that has precipitated changes in land tenure. The outcome has been alienation in the abscence of empowerment with a sense of ownership. This has caused disinclination to conserve natural resources but explot them for short term ends.

There is also the other dimension of rural people displacement by agricultural development. What is unavoidable is that with time, the traditional way of using land will undergone considerable modification. More change will come with investment in large-scale modern agriculture and big hydropower dams that encroach on traditional land. As a consequence, many can be permanently displaced and uprooted due to lasting changes in their habitat. However, natural resources conservation and development are interdependent. They are not mutually exclusive since they are two side of the same coin. And, conditions can be made favourable for development with the essential ingredients and adequate knowledge provided. Therefore, the danger can be minimized with coordinated and integrated effort to ensure sustainable land management with lessons learnt from past unfavorable repercussions. This seeks a streamlined and earnest environmental impact assessment that addresses the natural resource endowment and society of which farmers and pastoralists are integral part.

In another note, climate shift has caused recurrent drought as a major meteorological component with severe disruption of ecosystems. Famine has also resulted in disaster on biodiversity, human and animal population. This has caused food insecurity. Then, people who often remain where they are, find it necessary to migrate temporarily or permanently when their original habitat can no longer meet their basic needs. Since their life is based on agriculture and natural resources exploitation, they leave a trail of destruction when they vote with their feet to settle elsewhere. Even their resettlement in new areas has led to short-lived pilage of natural resources. Instead, the integration of exotic species can help sustain the use of ecosystems such that the threshold beyond which there is no return will not be reached.

The reduced capacity of ecosystems to regenerate themselves either to natural or man-made causes has also meant the loss of cultural diversity. This can accelerate the magnitude and pace of natural resource erosin. It can even lead to to natural resources deterioration and the environment degradation merry-go-round. The reason is not far to seek. Traditionaly communities had developed distict names for indigenous forests and described their properties with a view of their utilization. But, the decline in culture-based knowledge has represented the erosion of human intellectual capital. Then, communities may lose interest in biodiversity conservation. In contrast, the innovation and creativity that reside in rural societies has been emotive. Until recently, only lip service was paid to the enhancement of indigenous biodiversity. At best, it enjoyed fickle public popularity and was a perennial ‘soft’

policy issue. This is despite the over fifty percent woodland and woody vegetation cover of the country (63).

Fortunately, the participation of communities in the management and sustainable utilization of natural resources has now been recognized. As a result, green growth and development has acquired political energy with demonstrated staying power. Efforts are also underway to implement programs that integrate indigenous knowledge with science and technology. This offers discernible synergy in the protection of fragile ecosystems and rational use of natural resources. Steps are also being taken to reverse land degradation caused by over-exploitation of fragile resources. Among these are use of appropriate technology, improved seeds, amelioration of marginal soils with compost and inorganic fertilizers. On the whole, such provision have helped enterprising farmers to increase production in tune with nature while it has provided encouragement to those who are reluctant and fearful to abandon old ways. Equally, the need to meet forestry related chain demands including affordable energy is given focused attention.

Given the above scenario, a framework for a stronger linkage is necessary to properly manage and sustainably utilize exotic species such as eucalyptus. Then, the involvement of the public sector, scientists, communities, and the propelled role of the private sector would provide relief to indigenous forests, rehabilitate degraded landscape and offer huge socio-economic benefits. Then, the treasure house of research findings in the

archive if packaged, and new information that would generated can help ensure sustainability of agriculture and the ecology. If anything, it is vital as feulwood. Construction material, scaffold, transmission pole, and timber also fetch good price. This combined with the job opportunity created to a large number of people especially resource-poor groups and disadvantaged women. These could be involved in the production, maintenance, harvesting and wood processing to make a modest contribution to poverty reduction and improved quality of life.

Origin

Eucalyptus is one of the diverse genus of flowering plants in the world. It belongs to the family *Myrtaceae*, subfamily *Myrotideae* 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 Labillardiére 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 asl but extends beynd that in Ethiopia (22; 28; 51).

Global Distribution

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, Chaina, Spain, Israel, Ethiopia, Morocco, South Africa and Uganda In all, over ten million hectare of eucalypt are found in the tropics at the end of 1990 (22; 23). 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.

Introduction to Ethiopia

Indigenous forests stands, particularly *Juniperus procera*, *Olea europaea* and *Podocarpus falcatus* were being depleted in the country due to feulwood and construction material. This was even when supplimented by other woody biomass, manure and crop residue. As it is most of the natural forests have slow growth, limited regeneration capacity and low yield. This threathened the accelerated deforestation of what little natural forest remained with increased biodiversity erosion. Yet, there was their unavoidable use, especially in the newly established capital, Addis Ababa in the late nineteenth century. But, they did not sustain the growing demand of the population. This led to their scarcity. Thus, the eminent deficiency of feulwood and forest products loomed large.

It was thus necessary to introduce fast growing exotic species of high yield and regeneration ability to combat the impending crisis. It was with this realization, that Emperor Menelik II (1868-1907) introduced eucalyptus to Ethiopia in 1895 from different countries, mainly from Australi. Seedlings were raised in the palace nursery and planted in the city. To assure its fast dissemination, seeds and seedlings were distributed freely to landowner with tax relief as incentive. People were also encouraged to protect the major indigenous forests. The Emperor also employed expatriates to set up the first forestry law in which all forests were declared state property. Accordingly, 'Crown Forest Land' was set aside to conserve natural forests (8).

The species was also introduced in village to make rural households independent of natural forests. It was also grown in marshy areas, degraded landscapes, dwellings, churches, mosques, etc. Eventually, it spread to the mild mid-altitude and the cool highlands of more than 2000 m asl. In the course of time, it offered multi-purpose use especially as a feulwood 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 "*Qay bahar zaf*" and "*nech bahar zaf*", respectively (5; 7; 22; 53; 62; 63).

The earlier introductions, however, had narrow genetic base and species overlap. Hence, to diversify the species in different agro-ecological zones, further introductions were made by various organizations. The first of these is the one established in 1958 and the mid-1960s at the arboretum within the College of Agriculture and Mechanical Arts, the current Haromaya University (1). The Chilalo Agricultural Development Unit (CADU) and the Institute of Agricultural Research introduced and tested at Assela and Holetta additional species between 1967-1971. These were mainly from Australia, Tasmania, Holland, Tanzania, Lusoto, and Japan (8). Since then, quite a number of species have been introduced from Australia by the Forest Researc Cenetr ad established as long-term provenance trials.

In all, about sixty kinds of eucalyptus have been introduced to different regions of Ethiopia. Out of these the well adapted species such as *E. camaldulensis*, *E. globulus*, *E. grandis* and *E. saligna* are widely planted and have offered versatile multi-purpse uses of economic importance (62). Others such as *Cupressus, Casuarina, Juniperus* and a number of pines were later introduced from Portugal, Italy and Greece. (10). However, some were ill-adapted and died after a certain developmental stage. But a few have thrived (1; 10. 57; 63).

Country-wide expansion

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 centers, woodlots, homesteads, communal lands, schools, churches and monasteries (4). 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 diversifid their income (55). As a consequenc, 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.

Notwithstanding that, in the mid-1960s acute fuelwood shortfall was envisaged around Addis Ababa. This set in motion the urgent measures to counteract the possible threat. It was also noted that indigenous species could be further endangered where towns have mushroomed in the country. Therefore, the expansion of eucalypt plantation and the introduction of other fast-growing trees received support from the government (29; 53). As a result, large-scale eucalyptus plantations were established on land not suitable for crop production and with low soil fertility. In addition to sustained availability of feulwood, these helped rehabilitate degraded lands with steep slopes. Again, in line with such initiative, the ten year period from 1975 to 1985 saw increased bilateral and multilateral support for rural afforestation and peri-urban plantation.

In the initial phase, the African Development Fund and the World Bank supported major plantation development with *Eucalyptus globules,* or the 'white' eucalyptus, as the main species (53). The Addis-Bah Forestry Project (an acronym coined with *Addis* from Addis Ababa and *Bah* from Bahar Dar) developed thousand of hectares most of it around Addis Ababa to become the defining feature of the city. A few were also established around Bahar Dar in Adet. These were contour planted in catchments combined with terraces and check-dam. These are highly valued due to their multi-purpose use and have also helped reduce soil erosion and acted as a windbreak (10; 22; 60). The was also a vast plantation under the Arsi Forest Enterprise (the earlier Munesa Shashemene Forest Enterprise). It was supported by the Swedish International Development Agency. Further, the Sudano-Sahelian Office of the UN initiated a fuel wood plantations program and established over 9000 hactare, mostly in the central highlands (51; 52).

Community eucalyptus plantation was also accelerated through Food-for-Work of the U.N. World Food Programres. Thousands of hectae were established. The overall outcome is that Addis Ababa, Adama (Nazret), Bahir Dar, Dangla, Debre Berhan, Desse, and Gondar acquired large fuelwood plantations. Added to this are the eucalyptus owned by farmers and woodlot growers in many villages and small towns. In aggeregate, the species is now entrenched as an integral part of the Ethiopian landscape. Thus, there is over half million

hectare of eucalyptus under state plantations, community and private woodlots. This places Ethiopia among the ten major eucalyptus growing countries in the world. What is amazing is that more than eighty percent of the total was established in close to thirty years only. Therefore, eucalyptus is here to stay regardless of views to the contrary that flatly contrardict the objective reality on the ground. The viable optin to resolves ecological and agricultural related issues is implementation of sound land management.

Current Management and Utilization

General Consideration

Despite their slow growthe, farmers have conserved and even planted indigenous trees for diverse use. This is witnessed by the patches that dot the rural landscape. Conversely, eucalyptus is relatively of short rotation species. It has rapid growth and produces large quantity of biomass with the added advantage of its ability to coppice. As a biological land reclamation tool, the species is the last in the succession of land use. This is because it is adapted to a wide range of ecological conditions and sites. Thus, it does well where natural forests have been impoverished and where other biomas is hard to come by. Therefore, it has been indispensible to the rehabilitation of abandoned sites and on landscape too degraded to support crops. In the process, it has diversified the holdings and income of many farmers. Equally, such farmers have become free of the seasonal choirs associated with the cultivation of crops. Once established, the species continues to generate income through many coppice generations. Even then, many cultivate crops adjacent to eucalyptus to compensate for the gap that might be created by converting all of their farm land to eucalypt woodlot.

However, due to the convertion of farmlands in certain areas to eucalyptus, it has been considered not ecologically friendly. Indeed, the species can have negative consequences under poor management. This is the case where the wrong species is planted on improper site. The blame should then fall on the real culprit - bad management. Such criticism could equally apply to other large-sacle investment. In contrast, incentive is provided to such commercial enterprises as floriculture, horticulture and industrial crops that now dominate fertile landscapes. But instead of the prejeduce, eucalyptusit must be viewed in a similar manner to these enterprises under a land policy which makes agriculture and forestry complementary.

Management

The sound management of eucalyptus has to take into account the ecological sustainability of the landscape with little adverse impact on the surrounding. That farmers have long practiced farm forestry as one aspect of land use system has provided the experience to this end. This means they have perception of the factors that encourage or discourage their established farm practices. Accordingly, the perennial eucalyptus is incorporated into their farming system and is grown on homesteads in association with crops than other indigenous and exotic species. It is also planted as woodlot, farm-boundary and live fence further from crops to avoid possible interaction (15; 58). Accordingly, the ‘red’ eucalyptus is grown at warmer lower altitude and the ‘white’ eucalyptus on cooler higher altitude. Therefore, farmers take appropriate measures from initial seed bed preparation, seedling raising, transplanting to harvest given their acquired experience through the years. As a result, it has

offered benefits in the form of feulwood, poles, honey, shade for livestock, medicine etc. Such sustainable production of the species has enabled farmers to use manure and compost from crop residue for soil fertility enhancement rather than for the generation of household energy.

However, in many places, litter is collected as fuel and not allowed to accumulate. If maintained on the site, substantial amount of nutrients could have passed to the soil on decomposition. In some areas the site is also made weed free with the inversion of the soil to bury competing grasses. But, these could slow runoff and improve infiltration since it acts as a blanket against raindrop impact that causes soil detachment with increased erosion, especially on steep slopes. Fortunately, some practice agroforestry where leguminous trees that fix atmospheric nitrogen that improves soil fertility which in turn enhances productivity and production.

Eucalyptus is often established with vaying density from seedlings raised by farmers or obtained from government nurseries etc. Given their small land holding, it is planted at high density (58). It is even common to witness haphazard planting of 4,000 to 10,000, and in some cases, up to 40,000 plants per hectare. Unusually high density of over 100,000 trees per hectare have also been reported (5). Such high density makes eucalypts slender and low yielder. Since thinning is seldom done, it makes tending and harvesting difficult; that too with improper tools and technique. Further, fire incidence in such dense woodlots and large plantations is of concern. Its

volatile oil makes eucalyptus highly combustible specially during the dry season. Certain incidences have occurred and some were catastrophic.

Those farmers and woodlot growers that use wider spacing had faster tree growth and high volume yield. Bigger diameter poles are also obtained from the state-owned plantations that have been established with wider spacing (58). Such spacing has enabled the re-establishment of old stand, permited the removal of poor ones and left space for new planting. No less important, it has allowed limited penetration of sunlight to the forest floor. Thist has promoted other native tree species and lush grass to flourish underneath whereby eucalyptus has become a foster species. Some have also combined various soil conservation management techniques to minimizes surface runoff and reduce soil erosion with varying success. Among these are sunken hole, half moon, mulch and conventional pits on gullies, stony and steep land (42). Yet, monoculture eucalyptus is not the best solution to combat soil erosion (7). A more suitable approach could be a mixed stand of eucalyptus and leguminous trees. For instance, acacia is a good candidate since it fixes atmospheric nitrogen and improves soil fertiltiy.

Under sound management, eucalyptus can be harvested within four to five years. However, on heavy clay soils a longer period of eight to twelve years is needed (55). For the most part, it is harvested by clear felling using axe where the tree is cut at either too high from the ground or at the ground level. Thus, neither the appropriate tools or the right felling level is followed for the regeneration and survival of shoots. Instead of

such practice that causes bark damage, better coppice growth could be obtained by using chain saw. This allows the rapid formation of protective callus tissue such that small diameter boles could develop from dormant buds. Whatever coppice are generated have robust growth since they grow on developed existing root system and can be harvested in five to seven years. But, little thinning is done for diverse undergrowth vegetation to be established. Otherwise, cut-and-carry of grass could have offered additional benefit.

Utilization

Due to its long gestation period compared to cereal crops, eucalyptus would not offer sustained income to farmers on a year-to-year basis. However, the benefits from the species is greater over the rotation period than agricultural crops (6; 31; 58). This has helped farmers diversify their income and sustain their farming opertations. There is also a growing market in terms of wood product utilization from eucalyptus. It is extensively used as poles for power and telecommunication lines. It is also abundantly used in structural work as scaffold and for making crates for fruits etc. Because of that, there is an increasing trend to establish eucalyptus plantation in recent decades.

Traditionally, eucalyptus leaves have been used in the treatment of colds. At present, some small-scale enterprises and a limited number of private investors have embarked on the distillation of aromatic essential oils. A few wood processing plants also manufacture particleboard and hardboard. However,

its good potential as veneer, plywood, and pulp for paper making has as yet to be fully exploited (26). The utilization of the lumber that gives good appearance to cabinetwork and furniture is at an infant stage. In another note, women that have limited access to and control over productive assets are engaged in the collection of twigs and litter for sale. Testimony to this is the women that treck several kilometres to Intoto Mountain around Addis Ababa. They face great difficulties and danger (60). With proper support given the gender-oriented strategy to development, they could be organized into nature-based alternative income generating schemes. If they were to embark on establishing their own woodlot as small and micro-enterprise given their close touch with the sector, it adds another dimension to the productive engagement of women in eucalyptus forestry development.

In conclusion, it is possible to define the condition under which eucalyptus (and other exotic species) should be limited or where, when and how they should be promoted as ecologically appropriate species. Then, under knowledge-based actions that are immaculately planned and executed with precision to ensure participatory development, the species can relieve the pressure on indigenous trees as a foster species. With sound management, correct site-species mix, and genetic improvement, its efficient utilization can be sustained with little adverse impact on ecology and agriculture.

The Risk-Opprtunity Debat

General Consideration

Eucalyptus was introduced with the purpose of providing mult-purpose use and rescue the remaining indigenous forests from being destroyed. Despite this, negative perception has surrounded the species as far back as 1913, not long after its introduction. For instance, a directive was issued for people to uproot half of the ecalyptus planted in Addis Ababa (47). Therefore, the curse-blessing debate is not a new phenomenon. But, it is now more charged with a mixture of fact and fiction. To the opponenets, eucalyptus is an exotic species that has undesirable ecological qualities which is liable to create environmental degredation (34; 36). No less, it is claimed to have adverse impact on crop production and sustainable land use. This is from the assumed aggressive use of resources that precipitate soil fertility depletion and water deficit. Concern is also voiced over its inhibition of indigenous trees. It is equally accused of suppressing other vegetation from allelopathic chemicals that it produces. As a consequence, it is alleged to be unsuitabile habitat for wildlife.

The proponents recognize that the limited climax forests and woodlands are the last bastions and strongholds of indigenous natural resources in the country. The scattered and heavily disturbed patches of native forests found in remote parts of the

country are living testimony to this. As a result, prestine forests are protected at both the federal and regional level. The country has formulated policies and issued the first comprehensive proclamation in 1994 for the conservation, devlopment and utilization of natural resources and protection of the environment (Proc. No. 94/1994). In reference to the forestry sector, it has prohibited the harvest of *Hagenia abyssinica*, *Cordia Africana*, *Afrocarpus (Podicarpus) falcatus* and *Juniperus proceora* but allowed obtaining forest products for household use. Laws in later years have also addressed natural resources and the environment. Customized provision for the involvement of the private in forestry development have also been made.

The governments has also endorsed the National Conservation Strategy of Ethiopian and the Forestry Action Program. Invariablly, all the regional governments have also formulated their own tailored forestry action program that cover setoral and cross-cutting issues. Its put primary focus is on tree and forest; forest resources and ecosystem management; forest industries development; and feulwood energy efficiency development (15). Thus, plantation forestry is not precluded but is viewed as complimentary to the conservation of indigenous forest resources. This has been attested since where eucalyptus plantation has been established under sound managemt, the species has complimented natural forest conservation. As a foster species it has acted as a buffer against the erosion of forest biodivesrsity since it nurtured the regeneration of indegenous species from seeds that have stayed

viable in the soil. Asa result, it has promoted the rehabilitation of degraded landscapes with a host of rich vegetation established in its understory (14; 17; 18; 19; 20; 48; 49; 50). What has been demonstrated is that it is, among others, species-site mismatch and other poor management that are to blame. Then, eucalyptus should not be considered a culprit simply because it is an exotic species (34; 35; 36). Otherwise, development would be arrested. On the other hand, there is a more pressing concern to combat such invasive alien speciecis such as the acacia, *Prosopis* and the 'congress weed' *Parthenium.* Both have encroached on fertile agricultural land and displaced livestock in the fragile agro-pastoral and pastoral areas. Therefore, the debate on eucalyptus under the pretext of concern for indigenous forests is 'a storm in a tea cup' and must not dilte the urgent attention that should be given to these colonizers that continue to cause havoc in rural landscape.

At the face of such body of evidence, it is wrong to assume that only the side the opponents perceived exists and that the proponenets have only imagined what they did not observe. Again, in view of this, it is a contradiction to think that the little indigenous forests left would be replaced by eucalyptus. Instead, the concern has been and continues to be the conservation, rehabilitation and sustained utilization of these vital resources. To this end, there is compelling evidence that social mobilization under sustainable land management has promoted green growth and development with both exotic and indigenous forests to help diversify smallholder income and helped reduce poverty (32). Therefore, the attempt to establish

direct link between eucalyptus and ecological risk or biodiversity erosion is a misrpresentation of the reality. It only reveals that their subjective perception of eucalyptus has not embraced and even lacked contact with the objective gains from the species. If the prejudice with the desimination of such message persists, it can lead to scepticism in certain circles. It can even give the impression that the more eucalyptus is planted, the increased shortfall in agricultural production and the greater the loss of natural forest. This can obscure and negatively affect the immense importance that policy makers can play to provided the conducive atmosphere for exotic species establishment. But, more than one hundred year since its introduction, agricultural production has been maintained and streams continue to flow!

In contrast there is voluminous information that the primary cause for the destruction of natural resoutces is the accelerated human-induced causes. For the most part the negative externalities include the spread of sedentary agriculture, shifting cultivation, demand for feulwood and construction material. Climate change has also exacted its toll with visible impact on natural resources. But, at the face of climate change, its high biomass sequesters the greenhouse gas carbon dioxide. This adds value to its role in biodiversity conservation by being a carbon sink. As a case in point, the plantation around Intoto Mountain is claimed to be the lung of Addis Ababa. Given its contribution to cleaner environment, it could also be traded to finance future natural resources development.

Understandably, eucalyptus will not be appropriate in certain areas where the right conditions do not exist. This can be turned around through sound management without adverse impact on agriculture and the environment. Species that offer the best potential for the conversion of soil nutrients and water into biomass can be selected. Even if assumed to be a curse, sanity requires the recognition of the close to half a million hectares of eucalyptus in the country. It is too big to be ignored. To some, it is a blessing because it is a life saviour (30). Then, there is need to make the best out of the 'necessary eveil'. To this end, sound management that prescribes the boundry limits under which eucalyptus can be grown could be adopted to minimize the risks and maximize the opportunities that the species offers.

In this regard, farmers are not blind to its claimed negative ecological and agricultural impact. They have utilized the knowledge and experience hallowed by time to ensure sound eucalyptus production. Even *without* infusion of appropriate technology, there is increased allocation of resource and land for eucalyptus by farmers and wood lot growers. Then, ther primary focus must be the acquisition of the knowledge on what motivates farmers to embrace eucalyptus. With the insight and wisdom gained, the effort should be to win them *not* against their will but against their background. Then, a strengthened partnership with communities under benefit sharing arrangement can responed to their needs and make them active agents in the protectión of forests in step with the ruling cycle of nature. The recognition of this is important since people need

infrastructure, goods and service that involve use of forest resources, both indigenous and exotic.

This can be undertaken through sustainable land management that is now being implemented with the needs of rural communities and other end users taken into consideration. It recognizes the comparative advantage that can be obtained from different land use options. Hence, as a *natural* capital, eucalyptus that offers multi-purpose benefits and fetches a good price, should not be viewd different from crop production. If a price tag has been placed on the provision of feulwood, timber, essential oil, soil and biodiversity conservation from afforestation, it would not be difficult to realize that eucalyptus has made substantial contribution to the economy of the country. These would have been foregone without the species. With this in perspective, the diverse views are scrutinized based on empirical evidence such that the debate on eucalyptus will not gravitate into a myth.

Comptition for Water

Natural ecosystems are fundamental in regulating water quantity and quality. But, deforestation and poor land management have resulted in accelerated ersosion, heightened the incidence and degree of flooding, reduced the recharge of ground water, increased the sediment load of rivers and accelerated the siltation of reservoirs. Therefore, exotic species that have helped in the rehabilitation of degraded landscape and assisted to maintain the ecological integrity of landscapes should be considered integral part in the conservation of water

resources. Indeed, eucalyptus has been traditionally planted, to drain swamps and flooded areas. For the most part, the aim was to control the breeding of mosquitoes. It was also used for the restoration of marshy areas for various purposes, including agriculture. The poor soil aeration or low oxygen level in crop land where excess soil water does not move freely downward retards nutrient and water absorption, which in turn restricts plant metabolism and growth (10). This was counter-balanced by the versatile eucalyptus. This has given the impression that eucalyptus is a hugr water consumer and that it does not supplement but compromise crop production. It is even argued that it absorbes more water from the soil than any other tree species and agricultural crops.

In reference to the relationship between plants and water, there are several factors to be considered. First, of the rainfall that reaches a forest soil, there is the amount of water that is intercepted by the tree canopy. Of this, part is absorbed by the soil and the rest is lost as runsoff. Out of the amount absorbed, part is used by the plant. However, a stream of water flows from the soil into the root, through the stem and into the leaf to be lost as evapotranspiration. This lowers the moisture content of the soil. And, the soil water may not be replenished by rain over periods of weeks or months. This brings us to such 'old' concept as gravitational water, field capacity and permananet wilting point. (These terms are chosen because they are easy to understand than the more technical current concept of soil water potential).

To begin with, with heavy rain the soil becomes saturated and the water is detained briefly. Such water dilutes the soil solution and plant roots my find it difficult to cope with nutrient deficiency. The increase in soil moisture content also means that aeration becomes limiting for root growth and activity. But, eucalyptus not only copes with it but also flourishes on marshy areas. Under normal condition such water gradually moves downward freely as gravitational water. After the excess water is drained, a certain amount remains in the soil and it is regarded as the field capacity of the soil. This water content of the soil after the excess is removed is the upper limit of soil water content that would be available to plants. This varies on the nature of the soil. A clay soil with fine pores has a higher field capacity and drains slowly. A sandy soil with larger pore space has a lower field capacity and drains fast. Then, eucalyptus must perform poorly on sandy soils; but it does not.

On the other hand, water is lost continuously from the soil by evaporation. A stream of water also flows from the soil into the root, through the stem and into the leaf to be lost as evapotranspiration from plants. This is aggravated during an extended dry season where the volume of the soil solution would shrink and the concentration of solutes in the soil could rise. Such a dry period may also cause mehanical impedence and impair water absorption through root extension and growth. If dry period is sever, plants wilt permananetly. Then, growth ceases and death from dessication could occur. This is the permananet wilting point. It is the lower limit of soil water when leaves fail to regain turgor. An important factor is that a clay soil has a much

higher permananet wilting point than a sandy soil. Thus, as the water in the vicinity of the root is depleted, moisture stress increases faster for a sandy soil of little water holding capacity than for a clay soil that has finer capillaries to retains water. As water moves from the remaining soil mass to the root, the stress decreases faster for clay than for a sandy soil. Yet, eucalyptus has robust growth with high biomas yield under high soil moisture stress on degraded soils and even volcanic ash materials that are not regarded as soil in the true sense of the word. Hence, eucalyptus has marked versatility to the two extremes of wet and dry soil conditionsd and copes with the two-way traffic of materials between roots and shoots. These attributes characterizes the species as a paradigm of adaptation. Testimony to this is the plantation on the Intoto Mountain range around Addis Ababa and similar setting elsewhere in the country.

What allows eucalyptus to perform successfully in the vast array of contrasting adverse conditions is the low surface area of its elongated crown, the wax coating on its leaves to combat evaporation, closure of the stomata when water deficit in the leaf is high, and its vertical roots with ability to exploite water from deeper soil horizons outside the realm of crops feeding zone. Because of these factors, the species has greater water use efficiency per unit of biomass produced unlike many trees and food crops (7; 8; 22; 55). Therefore, the claim that it is water demanding and noticeably reduce crop yields due to water depletion is over exaggerated. It can only be true under poor site-species management. But, from the perspective of farmers, eucalyptus influences the micro-climate and

contributes to increased rainfall. In spite of this, the exclusion of eucalypts in watershed development has been advocated though its establishment in high rainfall regimes should not be of major concern. After all, this is where farmers drain excess rain water from their farms such that it would not limits crop production.

Soil Fertility Depletion

The species is claimed to extracts substantial amount of nutrients and compete with crops while at the same time impoverish the soil (7; 22; 37; 38). It could be legitimate to raise such concern under poor management where there is lack of species-site match. Such could be the case on soils where the continuum between the species and soil could be disrupted. Essential nutrients for plant growth are continuously removed from one end of the system, the soil, move through the soil solution to the plant root and are accumulated at the other end, the plant top. But, nutrient loss from the soil or input to the soil occur and this is proportional to the intensity of the processes involved. Constant internal and external fluxes occur and these lead to non-equilibrium conditions. Further, the soil environment under which the species is established may not possess the combination of desirable features in space and time. As a case in point, an ‘ideal' soil is expected to provide a balanced supply of plant nutrients from minerals and organic matter; capacity to store and release water and nutrients to roots; adequate depth with good permeability for root growth; and optimum soil water infiltration with minimum water

logging. But, an ideal condition is rarely attained. It varies according to the dynamic interactions involved between the species and the heterogeneous soil as a potent ecological factor.

Yet, incapable of locomotion, eucalyptus must withstand the wide great range of condition encountered within the soil. It copes with such variability through a root system that has intimate contact with the large volume of soil. With the extention of its root deep into the soil, given its high degree of adaptability, it extracts nutrients outside the realm of crops feeding zone. That is why its nutrient requirement is significantly lower than that of many agricultural crops (66; 67). As a result, the species flourishes with sustainable high yield *without* fertilizer on red ash and degraded land. Further, eucalyptus is not a natural forest that has little disturbance. If it were a *closed* system, nutrients would have been recycled from decomposing litter back to the tree and increase the nutrient bank (60). But, eucalyptus is an *open* system and nutrients are removed from the site when the stem, leaves and bark are harvested for various uses. (37; 38). This means that the nutrient capital of the soil could be diminished. Therefore, the secret lies in *nutrient minng.* This is equally true for crops under poor management. However, retention of foliage at the site is not the ultimate measure to counter-balance the upset status between soil and the species. Under viable environment, soil nutrient levels can be improved through sound management without the carrying capacity of land being over-stretched. Among these is the integration of traditional practices of land management with appropriate knowledge and

technology. Specfically, it is possible to mix the species with legumes and this could be easily accepted since farmers have practiced traditional agroforestry. The use mulch, compost, fertilizers and other amendments can be efficient and cost-effective under proper species-site and spacing. Their adoption can help transform existing practices and be remunerative such that plantation forest can sustain agriculture without disturbing the ecology.

Plant Competition

One of the criticisms associated with eucalyptus is that it prohibits the establishment of understory plant species. Eucalyptus is usually taller than other plants of equal age. This has determined the amount of gap that would be available for sunlight to penetrate through its canopy. When planted at high density the shade created has adverse influences on the understory environment. The consequence could be vegetation free surface. The dense stand not only affects the growth of colonizing woody species, but also nearby crops given the added competition for water and nutrients. Then, yields from crops close to eucalyptus may not be as good as those further from the edge (10). Then, it is not eucalyptus *per se* but the lack of sound management that is to blame.

On the other hand, not all eucalyptus species cast heavy shadow to discourage understory plants. Some even cast less shade than broad-leaved trees because they have often narrow, patchy crowns and leaves positioned downwards on the twigs (65). As a case in point, several eucalyptus plantations in

different agro-ecological zones showed richness of herbaceous plant species than under adjacent natural forest. Further, the less dense plantations harboured more regenerated indigenous woody tree species than high dense eucalyptus stands (14; 18; 46; 49; 53; 65). This indicates that an inverse relationship exists between eucalyptus density and diversity of the regenerated species. In relation to economic crop, wheat production was not affected by eucalyptus on heavy clay soil (55). When used as shade tree for coffee, its cup quality was acceptable as that within the indigenous forest (56). Then, as a foster crop it offers an opportunity for rapid and productive multi-sectoral development in the country.

Biodiversity Erosion

Forests and other native vegetation have developed over millennia and achieved adaptation to varied and variable environmental condition in the country. Among these are tolerance to drought, waterlogging, low fertility, salinity, resistance to drought, tolerance to disease, insects and pests. Against this background, an important element in the debate is the threat of eucalyptus to ecosystem rich in forest biodiversity (34; 35; 36). But, prestine forests are under *in situ* conservation within the natural ecosystem. In areas where there is a high pressure on forests it could be difflicult to sustain them. Then, fast growing exotic trees could reconcile conservation with immediate basic human needs. This is where eucalyptus comes in *not* to substitute but to act as a *buffer* and protect the diminished natural resources. Still, their sustainability depends on the long term protection by administrative measures that

includes public awareness creation and suitable participatory silvicultural measures. Still, they may be susceptible to calamitie from biotic and abiotic factors such as disease, pests, drought and fire.

Current reality is that only patches of indigenous forests with limited species diversity are found in protected forests and inaccessible remote areas. These isolated forests have low population dynamic. They can be affected by climate change and have to be maintained as important sources of seed. Churches, mosques and traditional burial sites also own and protect ramnant 'sacred' forests (4). Obviously, these are not only natural heritage but they may also posess as yet not known or recognized potential uses. Hence, their *in situ* conservation is a must and a necessity to provide sustainable benefits to present generation while help meet the needs and aspirations of future generations. That is why they can *not* be part of the controversy since eucalyptus is not planted to replace what little is left.

Conversely, under sound management, deforested barren landscapes and degrade lands when covered by exotic tree species have provided dividends. As a matter of fact, where eucalyptus was established as a plantation on land that once had a natural forest, seedlings from long-lived seeds that have accumulated over the years after the disturbance of the site have remained viable and established. This is partly because the species creates a favourable environment for sufficient light to filter through the canopy and protect seedlings from

scorching sunlight. Since there is less direct sunlight, the humidity inside a plantation is often higher and the average temperature lower than outside (10). Equally, the canopy acts as a break against desiccating winds. Hence, it has a positive impact on the rehabilitation of forest biodiversity. Becasue it has enhanced natural resources conservation with the regeneration and re-colonization of native species from such soil seed bank the 'catalyst' eucalyptus is now considered a foster species (9; 11; 12; 14; 17; 27; 48; 49; 50; 64; 65; 66).

This was the case in the Munesa-Shashemene plantation that has fostered natural regeneration of several native species from such gene pool (18**;** 66). Similarly, the once degraded Intoto Mountain around Addis Ababa has a mixture of indigenous forest unde eucalyptus plantation (33; 40). Elsewhere, outside eucalyptus plantation as for instance in the Afromontane forests of Gara`Ades, Menagesha, Munessa-Shashemnene, and Wof-Washa the soil seed flora ranged from 68 species at Munessa-Shashemnene and 92 at Gara`Ades while the viable seed ranged between 12,000 per square meter at Menagesha to 24,000 at Wof-Washa (9). These have served as 'genetic memory' of past vegetation types and their resurgence has importance in the dynamics of plant biodiversity.

Scarcity of Wildlife

Ethiopia has diverse wildlife of world importance. Yet, there has been the erosion of these resources due to the destruction of their habitat from introduction of agriculture, recurrent drought, war and conflict. A few are found in parks and

sacnctuaries but a foolproof system has not been in place for their sound utilization. However, a growing concern is voiced from the claim of competion between wildlife and crop/livestock. Among others, the unpalatability of eucalyptus leaves is supposed to reduce the number of wildlife and livestock in an area. Due to its competitive nature, eucalyptus is considered not to provide adequate fodder to wildelife (22; 36). There is thus the debate as to whether wildlife would remain in their newly established eucalyptus habitat.

In the first place, eucalyptus is never established in natural forests that harbour wildlife. If there were some in the landscape, the destruction of the habitat might have forced them to migrates; obviously *prior* to eucalyptus. Then, it is difficult to imagine that degraded area, barren and treeless landscape could have provide the conducive habitat to wildlife. Instead, they would migrate due to deforestation of the original forest. The subjective perception of the species is in the abscence of ojective studies which demonstrate that eucalyptus plantation hosts lower wildlife population compared to a barren landscape that is now rehabilitated with indigenous species under a similar setting. The objective reality, however, is that with the establishment of eucalyptus, the canopy has provided shade for the emergence of undergrowth vegetation and the regeneration of indegenous trees. Now that they have a conducive habitat, some of the wildlife have returned (16; 17; 18). As a case in point the scenic evergreen eucalyptus plantation on Intoto Mountain that surounds Addis Ababa. It

hosts diverse wildlife even with large human population around and has become a prime destination to tourists.

Further, the flower of eucalyptus that produces abundant pollen and nectar has been essential in the life cycles of many insects and birds (7; 8; 22; 52; 53). These are important in the pollination of crops and bees provide additional benefit through production of honey. This has become a lucrative business to many rural communities. Under sound management similar plantations could exploit such potential without adverse effect on the ecology or crops. Palatable leguminous trees, shrubs, forages, pastures, and grasses can also be established under appropriate sound management. Then, such rehabilitated areas can be made favourable to wildlife instead of the categorical accusation of eycalyptus as detterent to their proliferation.

Allelopathy

Allelopathy is an interaction among plants by means of chemical compounds that exist in natural plant communities. Such allelochemicals can be present in soils, leaves, stems, roots, flowers, and seeds. They are released into the environment by several mechanisms such as leaching from the above ground parts, root exudation, volatilization, and residue decomposition. Their interaction with the plant for the most part has negative consequence on biological processes. They can effect germination and growth of plants through interference in cell division, energy metabolism, nutrient uptake etc. (37; 39; 60; 65). In this regard, eucalyptus has toxic allelochemicals that consist of phenolic acids, tannins, and

flavonoids (65).When realesed into the soil, these inhibit other plants and play a role in shaping plant communities. For instance, leaf decomposition product from eucalyptus is shown to suppressed germination and growth of chickpea, field pea, maize, and tef (37) while it exerted an antibiotic effect on soil microorganisms (48).

But, concentration matters. For instance, allelochemicals from decomposed eucalyptus litter in high rainfall areas did not accumulate in sufficient concentration to affect seed germination and root growth of crops. Different strength of water extract from leaves of eucalyptus did not delay the onset of germination and seedling growth of *Olea* (12; 65;48; 49). In fact, positive results have also been reported concerning the interaction of eucalyptus with other plants (55). The lack of susceptibility of certain crops and the regeneration of other species suggest that eucalyptus provides some benefit rather harm. Again, it is not only eucalyptus but other exotic tree species such as *Grevillea robusta* which is a common feature in Ethiopia has allelopathic effects on most agricultural crops (60).

Therefore, empirical information is needed to resolve such negative effect. Until then, allelopathy can be minimized with sound management through compatible crops based on proper eucalyptus species-site selection. It is, therefore, incumbent on the scientific community, in particular forestry research, to clearly articulate the setting under which exotic species in general and eucalyptus in particular, should be limited to avoid

the negative impact on habitat or promoted where it is ecology-oriented.

Areas of Focus on the Road Ahead

General Consideration

It has been stressed that the few pristine forests are among the last stronghold of biodiversity in the country. Therefore, the new frontier of eucalyptus plantation (and other exotic species) should be seen as an opportunity and not a threat to the ecology, indigenous flora and agriculture. To this end, site specific information is needed on whether the species contravens biodiversity, native species, wildlife, crops etc. This is vital to those that have to make evidence-based decision. No less, the private sector must have packages of technology in a usable form for wise investment that guarantee remunerative returns. This again calls for periodic socio-economic study given the dynamic fluctuation of the market. With this in perspective, some of the specific concers that seek focused attention in relation to eucalyptus are treated below.

Indigenous Species

Indigenous trees have been over exploited for various purposes. Conversely, monoculture of fast growing exotic species are often inferior to native species in terms of ecological sustainability (20; 21). Efforts to improve their long rotation age and low yield has not received adequate scientific investigation though some advances have been lately on their rapid propagation (34; 35). The pursuit of clone development from outstanding trees can provide a buffer since it captures the

essence of the plant without gene recombination that often occurs in seeds. This has to be complimented with knowledge on their growth characteristics, genetic, physiology, reproductive biology, silviculture, nutrient needs, water relation etc. Breakthrough in these areas could offer ample opportunity to restore the edangered indigenous species and also encourage their large-scale plantation. Such background information can equally help define the conditions under which they can be combined with exotic species to diversify species composition.

Genetic Base of Eucalyptus

There is little information on the first limited introduction whose genetic base, as a result, is narrow. Again, no systematic selection of the best-performing provenance was made. Some may be hybrids when introduced and there is the potential of in-breeding since then (8; 15; 58; 59). In contras, long term trials can come up with more productive species can replace some of the inferior eucalyptus species. Sustainable gains can also be made from hybrization of eucalyptus to enhance the attractiveness of specific combinations. This could be complemented by clones developed from outstanding trees with desirable traits to renew diversity across space and time. Therefore, with capacity built to strengthen the breeding program, new generations of eucalyptus can be made available for long term benefit. Simultaneously, For a start, the assessment of the existing stock to strengthen their sound management is necessary. At the same time, the maintainance under *ex-situ* conservation of new introductions with genetic

variation has to be fine tuned as insurance against loss of the genetic base. It could be useful in selection and breeding for future improvement of the species. Otherwise, the limited number of genotypes could increase the risk of susceptibility to disease, pest, and bring about changes in the final product.

Forest Biodiversity

Climate change with extremes of temperature and erratic rainfall, can bring about complex alteration in vegetation pattern. It can change species composition, reduce biodiversity. From not sustainable development pathways critical limit could be exceeded and threahen habitat threahen habitat due to the multiplier effect of a growing population that can compromise the overall ecological integrity of the landscape. Then, biologically diverse and ecologically stable sustainable forest is imperative. To this end, research is needed on the conservation of indigenous forests, their natural or assisted regeneration with resilence and their production under different management. The innovation and creativity that reside in rural societies has to be acknowledged and the culture-based knowledge has to be documented as human intellectual capital. This goes a long way towards a win-win situation with the enhancement of indigenous biodiversity to ensure their conservation and sustained utilization.

As part of this strategy, there is the need for a proper institutional mechanism to assess the carbon sequestration capacity of indigenous forest species under benefit sharing arrangement. Then, the country would benefit from carbon

trading for a substantial long term impact on overall forest biodiversity protection and development while maintaining a cleaner environment. This could accelerate massive afforestation with mixed indigenous and exotic species, including eucalyptus. Hence, there is need to explore the opportunities, limitations and acceptance of native specie with different growth characteristics in relation to eucalyptus.

Timber

Eucalyptus that has top pulping quality due to its high fiber yields can help the expansion of wood processing industries. The mechanical properties of the timber also offer high potential for several applications (26). Hence, under suitable market arrangement, forest-based enterprises can contributes to its efficient utilization. However, the basic characteristics of the species are not well known by the limited processors around. For instance, the slow drying of eucalypts due to its high density and tendency to crack continues to be a technological challenge that has limited its industrial use. Thus, information and technologies on its proper processing, handling and management is vital for its efficient utilization.

On the whole, there is need to further generate information on the physical, seasoning and mechanical characteristics of species and rational utilization technologies; evaluate natural durability of timbers, select efficient preservative application techniques, treatability with-and- effectiveness of preservatives against subterranean termites and fungal attack; and highlight wood working properties and potential uses. The comparison

with other native and exotic species could offer alternatives to the wood industry. This is an area that must be strengthened given the huge amount of timber imported into the country with immense foreign exchange.

Energy

The bulk of the household energy is obtained from biomass due to the abscencee of other energy source. Again, with the wind of change in the country, it has been difficult to kept pace with the increasing demand for energy from biomass. Such over-dependence has continued to be critical to sustainable land use. This could further deplet the few pristine forests that remain. On the other hand, the woody biomass production of eucalyptus is high and its biofuel quality is good (26). Thus, its stems, branches, twigs, and leaves have helped meet cooking and space heating needs of both rural and urban areas. This means that it is hardly possible to stop the expansion of eucalyptus through discouragement or banning.

Part of the answer lies in the development and utilization of appropriate, efficient, and cost-effective small-scale technology to provide clean energy. Eucalypts with its high biomass offers immense potential for long term production of renewable energy and power. Then, value added can be to pelleted residue such as sawdust, shaving and other materials recovered from timber processing. This should arouse great interest. Some advances have been made in this area (26). If streamlined, and strengthened, such sources as raw material could encourage

massive afforestation of exotic species and the establishment of prívate plantation under benefit sharing arrangement.

When complemented by other reliable clean sources, greater synergy can be obtained in the reduction of carbon dioxide and other greenhouses gases. In the process, not only would there be a cleaner environment, but it also offers a window opportunity for carbon trading under the proper institutional arrangement. The carbon offsets and environmental service from several native species, large-scale peri-urban eucalyptus plantations, and smallholder rural woodlots could be substantial. As a consequence, the carbon credit trade could have a long term impact on adaptation with increased investment on green development to mitigate the shocks due to climate change and environmental degradation. However, the quantification of their carbon sequestration capacity has not been undertaken to infuse knowledge and technology towards the increased development of mixed forests to tap the benefits from the global climate debate and assure additional revenue. In another note, eucalyptus plantation and other biophysical conservation measures can support the energy sectors since watershed protection is much cheaper and environmentally sound option than engineering solutions to sustain hydroelectric dams. Then, complementarity must exist between agriculture, forestry and energy for the integrated utilization of resources under diverse ecology.

Essential Oil

Leaves of eucalyptus have been traditionally used in the treatment of colds. It is rich in oil glands of fragrance and is a

source of notable aromatic essential oils that are complex mixtures of volatile organic compound and are obtained by steam-distillation of leaves, though found in fruits, buds, and bark (57; 69). On commercial scale, its preparation is used as chest rub, nasal inhalant, cough drops, disinfectant and insect repellent. It is also used in perfumes, soaps, as air refreshner, and solvent especially as paint thinner. Therefore, essentail oil has been widely used by countries like South Africa, Portugal, Spain, Brazil, Australia, Chile and Swaziland (57; 69). But, despite the over half million hectares of eucalyptus in the country, and given the immense potential to produce essential oil, only a few private companies are engaged in its production (57). Its use continues to be restricted mainly as feul wood and construction material. Yet, the country continues to import essential oils while its production could have been scaled-up for contribution to the national economy through import substitution and as a source of foreign exchange.

Therefore, the production of essential oil must be encouraged with the improvement in the efficiency of distillation technology that enhance the quality and quantity of the oil extracted. At the same time, research in partnership with relevant stakeholders needs to answer vital questions. Thses relate to oil yield as determined by biomass production and age of leaves at harvest, site-specific edaphic features such as soil fertility etc (13; 57). Equally, the selection of high yielding eucalyptus species and breeding t are crucial for profitabile venture. In addition to research-based technology the private sector as to be encouraged to invest in its production from

existing vast resource while at the same time establish aromatic eucalyptus plantation that have high essential oils production.

Diseases and Fire Incidence

Diseases could have serious impacts on plantation forests. Hitherto, eucucalyptus has been relatively free of diseases. Attack of juvenile leaves by aphid have occured but these disappear when the leaves develop. In recent years, however, tree deaths have become frequent. These have been attributed to poor site, poor management and adverse climatic conditions (2; 3). In some cases, it has resulted in the abandon or restriction of the species to specific localities. On the other hand, several fungal pathogens are noted to infect stems, roots, and leaves with considerable damage (3). Yet, with the vast resource in the country and where farmers continue to expand eucalyptus and even replace vast areas of productive agricultural land by the species, the fast spread of pest, diseases, biotic, and abiotic stresses could lead to production nightmare. But, their role in tree death is underestimated, poorly understood and has not been studied in detail (2). It seeks adequate attention with the capacity of research in this area strengthened. In parallel, the work on eucalyptus diversification should continue in the event that the widely planted species are attacked by biotic and abiotic factors to create havoc.

Another concern is the risk of fire incidence. Due to the large amount of litter produced that contain highly combustible volatile oils eucalyptus is susceptible to fire during the dry

season (60). So far, fire incidence has not been a major problem. But, it can be devastating unless fire-break corridors are provided. These are visibly absent and so are the gears needed for a fire brigade to combat major fires. Hence, detailed assessment of the plantations has to be made and various mechanisms have to be put in place. This could also protect indigenous forests given some of the catastrophic forest fire incidences that have occurred during the dry season.

Allelopathy

Eucalyptus has allelochemicals that consist of phenolic acids, tannins, and flavonoids (65). Their interaction with plants for the most part, has negative consequence (14; 19; 37; 39; 60; 65; 67). In this regard, previous investigations have been primarily concerned with agricultural crops given the concern for high productivity and production. Thus, attention has to be given to better understand the mechanisms involved by allelochemicals as determinant to different plant communities. How best to minimize its effect seeks investigation since its may depend on many factors including species-site conditions and management practices. Accordingly, species that foster native species regeneration without negative effects on biodiversity and the environment could be selected.

Phytoremediation

Chemical agents have been employed with long-term applicability to mitigate the adverse impact of heavy metals like lead and chromium on the environment. The technology has aesthetic advantage and has been demonstrated to be cost-

effective (44). Currently, heavy metal contamination of some areas and river bodies from both liquid and solid waste have become visible. What is conspicuous is the discharge of toxic affluents from tanneries and unrban centers. This had detrimental environmental impact. Conversely, such contaminated sites can be reclaimed, at least in part, by using eucalyptus. It accumulates the toxic metals and translocates them to the above ground parts from where they are eventually removed as wood products. Therefore, its wide application for management must be explored through both basic and applied reaserch.

In aggregate, the forestry sector must accept the challenge to continuously supply new research and development information to users. Equally, hitherto findings that are now in the "archives" have to be packaged in a usable form. These can weigh the trade-off between the various benefits and risks to come up with alternatives that makes eucalyptus ecologically and agriculturally friendly. Then, it is possible to change the wrong perception on the renewable versatile species wher it development (and other exotic species) can contribute toward improved livelihood.

Institutional Arrangement

Through the years the vast forestry sector has been a casualty of constant reshuffle. For the most part it was under the Ministry of Agriculture later the Ministry of Agriculture and Environment Protection. In the process, it has been repeatedly restructured as: State Forest Development Agencey, State

Forest Conservation and Development Department, Community Foreests, Soils Conservation and Development Department, and Forestry and Wildlife Conservation and Development Agency. Eventually, it was amalgamated with the Ministry of Natural Resources Development and Environmental Protection in the early 1990s (15, 68). This was the first time that organic linkage was established between the diverse renewable natural resources under one ministry. It has allowed an amicable balance between agriculture development and natural resources conservation. But, it sublimed!

Once again, the pendulum swung! The sector was transferred back to the Ministry of Agriculture where its 'residence' there for more than a decade was marked with its shrivel. It ended up with a team that had only a handful staff. Yet, it is supposed to be the stewrd of the vast forests and woodlands resource the cover about fifty percent of the country (63). Hence, the critical challenge of the sector was instability with erosin of institutional memory with loss of demand-driven and action-oriented success stories that could have been adopted. This has constrained the development of the sector. This is a reminder of the reflection "*We trained hard – but it seemed that every time we were beginning to form into teams we were reorganized. I was to learn later in life that we need to meet any new situation by reorganizing, and what a wonderful method it can be for creating the illusion of progress while actually producing confusion, inefficiency, and demoralization."* It is calimed to have been made by Petronious Arbiteras as far back as 210 B.C. Indeed, it rings true even after 2000 years!

After years of the ever-changing instutional arrangement, the sector became part of the new formed Ministry of Forestry and Environment in 2013. The establishment of the Ministry is a positive step. It has given a face lift to the forestry sector and has upgraded the Environment Protection Authority to the level of a ministry. One hopes that it would be a stable institution. Then, under streamlined instruments capacity can be built for research and extension to be harmonized and inter-linked with education and training. Under this setting, knowledge and appropriate technology packaged in a usable form can be delivered for the sound management of the forestry sector and the environment.

Policy

The authors recognize with appreciation the green development effort of the government, and communities in the conservation-based sound management and sustained utilization of ecosytmes. The social mobilization under sustainable land management has offered knowledge-based management options to fight deforestation, land degradation and rehabilitate the landscape. We also recognize the move to create awareness such that a well informed and conscious community would be the watchdog of natural resources and the environment. That is why various policy and strategy isues have been sprinkled throughout the text to supplement such noble undertaking. Yet, a few key sectoral and cross-sectoral policy issues are raised to reconcile eucalyptus with agriculture and non-agricultural growth.

At the face of heightened climate risks, the harmonization of forestry and agriculture policy unquestionably helps combat food insecurity and poverty. In reference to eucalyptus, as elaborated, the evidence so far reveals that the species will continue to figure prominenetly in the life of both rural and urban people. Then, its legitimate place in the development policy of the country menas that individuals and communities can be encourage to accelerate the establishment of commercial exotic plantation and indigenous forest that will not contraven the ecology.

Investment can also be viable and be remunerative through provision of credit and/or incentive. It would allow the wood product industries to abandon wasteful old ways and embrace efficient use-friendly technologies. Such support when it goes hand in hand with improved market chains can foster import substitution and ensure foreign exchange earning given the booming demand for various wood products at home and abroad. Therefore, such a scheme must be seen in a manner similar to the many-layered incentive that is provided to floriculture, horticulture, mechanized agriculture and other investments with mixed results. Where there has not been in-depth land suitability and capability classification some have displaced productive cropland. Othets have caused the denudation of native vegetation and natural forests. Instead, crtical environment impact assessment could have averted the situation. What is anomalous is that eucalyptus is discouraged to mitgate these same concerns despite the reality on the ground to the contrary.

Therefore, different options on eucalyptus should be made based on its economic valuation in terms of consumption or depreciation of agricultural peroducts or natural resources depletion due to the species. Such an approach with incentives provided can promote agricultural, non-agricultural and industrial investments that create additional employment. For one, small scale farmers, woodlot growers and micro-enterprises can generate additional income from sale of wood, essential oils and honey production. This offers synergy from increased carrying capacity of land. Equally, resource-poor farmers and women could establish their own woodlots. The whole scheme may even be as effective as subsidy, if not more. Its snowballing multiplier effect is the change in attitude of those that might be inflexible or are impervious to new ideas. As a result, they can become active partners in participatory forestry development that harmonizes agriculture with the ecological integrity of the landscape. This offers more than a glimmer of hope to the sustained development of the country such that life in different forms, key ecosystems, sensitive habitats, biodiversity, productive farmlands and water bodies would flourish. Then, there will be bloom and not doom from the valuable species.

References

1. Adugna Zerihun. 1981. Adapatability of several eucalyptus species in Hararghe Adminstration Region. Eth.J. of Agr. Sci. Vol. III(1), Addis Ababa University, Debre Zeit.
2. Alemu Gezahgne. 2010. Main diseases of Eucalyptus species in Ethiopia; pp. 351- 369. *In:* Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.
3. Alemu Gezahgne, J Roux, MJ Wingfield. 2003. Diseases of exotic plantation *Eucalyptus* and *Pinus* species in Ethiopia. South African J. Sci. 99:29-33.
4. Alemayehu Wassie, Demel Teketay, N Powell. 2005. Church forests in North Gonder Administrative Zone, Northern Ethiopia. Forests, Trees and Livelihoods. 15: 349-373
5. Amare Getahun. 2010. Eucalyptus farming in Ethiopia: The case of Eucalyptus farm and village woodlots in Amhara Region. pp 206 - 221 *In:* Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.
6. Daba Wirtu. 1998. The economics of growing *E. globulus* (labill.) in the highlands of Oromiya, Ethiopia. MSc thesis, Swedish University of Agricultural Sciences, Skinnskatteberg, Sweden.
7. Davidson J. 1989. The Eucalyptus dilemma. Arguments for and against Eucalyptus planting in Ethiopia. The Forestry Research Centre Seminar Note Series No. 1. Addis Ababa.
8. Davidson J. 1995. Eucalyptus tree improvement and breeding. Ministry of Natural Resources Development and Environmental Protection, Forestry Research Centre, Addis Ababa, Ethiopia.
9. Demel Teketay. 1996. Seed ecology and regeneration in afromontane forests of Ethiopia. Acta Universitatis Agriculture Sueciae, Silvestria, 4. Umeå, Sweden.
10. Demel Teketay. 2000. Facts and experience on eucalypts in Ethiopia and elsewhere: ground for making wise and informed decision. *Walia* 21: 25-46.
11. Desalegn Tadele. 2004. Growth and establishment of seedlings of indigenous species inside plantations and the adjacent natural forest. MSc thesis, Addis Ababa University, Addis Ababa.

12. Desalegn Tadele and Demel Teketay. 2010. Effects of extracts from leaves of Eucalyptus globulus Labill. on seed germination and early growth of Olea europaea L. subsp. cuspidata (Wall . ex G. Don) Cif. Pp. 81 -90 *In:* Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.

13. Ermias Dagne, Daniel Bisrat, Markos Alemayehu and Tadele Worku 2000. Essential oils of twelve Eucalyptus species from Ethiopia. Jour.o Essential Oils Research. 12, 467-470

14. Eshetu Yirdaw. 2001. Diversity of naturally regenerated native woody species in forest plantations in the Ethiopian highlands. New Forests 22: 159-177.

15. Ethiopian Forestry Action Plan. 1994. The Challenge for Development. Final Report. Vol. II. Ministry of Natural Resources Development and Environmental Protection, pp. 95.

16. Fekadu Debushe Teshome Soromessa Mekuria Argaw. 2010. Impacts of Eucalyptus globulus Labill. plantation on regeneration of woody species at Entoto Mountain, Addis Ababa. pp 310 – 320. *In:* Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp..

17. Feyera Senbeta, E Beck, U Luttge. 2002. Exotic trees as nurse-trees for the regeneration of natural tropical forests. *Trees* 16: 245-249.

18. _____ Demel Teketay. 2001. Regeneration of indigenous woody species under the canopy of tree plantations in Central Ethiopia. *Tropical Ecology* 42: 175-185.

19. _____ Demel Teketay, N Bert-Ake. 2002. Native woody species regeneration in exotic tree plantations at Munessa-Shashemene Forest, Southern Ethiopia. New Forests 24: 131-145.

20. _____ Aseffa Seyoum, and Tadesse Woldemariam. 2010. Is Eucalyptus farming blessing or curse in the Central Highlands of Ethiopia? Analysis from farmers' perspective. pp. 160 - 170 *In:* Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.

21. Feyisa Abate, Mebrate Mihretu. 1994. Provenance trial of *Cordia africana*. Provenance trials of some exotic and indigenous tree species. Research 3, 1-12.

22. Food and Agriculture Organization. 1988. The eucalyptus dilemma. Rome. 26pp.

23. _____ 1992. Mixed and pure forest plantations in the tropics and subtropics. FAO Forestry Paper 103. Rome, Italy.

24. _____ 1995. Flavours and fragances of plant origin. Series title: Non-Wood Forest Products - 1. 111 pp.

25. Getachew Desalegn, Wubalem Tadesse, Demel Teketay, Worku Fekadu, Gemechu Kaba and Girma Taye. 2007. Performance of preservative treatments on 32 timber tree species against termites and fungal attack at Bako, south western Ethiopia. SINET: Ethiop. J. Sci., 30(2):103–116.
26. _____and Alemu Ggezaghne, 2010. Timber properties of Eucalyptus species. Research Report No. 81. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia.
27. Getachew Tesfaye, Abyot Berhanu. 2006. Regeneration of indigenous woody species in the understory of exotic tree species plantations in southwestern Ethiopia. Ethiopian Jour. Biol. Sci. 5 (1): 31-43.
28. Gil, Luis. Wubalem Tadesse, Eduardo Tolosana, and Rosana Lopez (eds). 2010. Proceeding of the conference on: Eucaluptus Species management, History, Status and Trends in Ethiopia.15-17 September, 2910, Ethiopian Institute of Agricultural Research. Addis Ababa, Ethiopia. 409 pp.
29. Henery P. W. 1973. Notes on maps of the eucalyptus plantations around Addis Ababa and the Menagesha State Forest, Ethiopia. Overseas Development Agency. London. Misc. Report 150: 1-10.
30. Holden S, S. Benin, B. Shiferaw, J. Pender. 2003. Tree planting for poverty reduction in less-favoured areas of the Ethiopian highlands. Small-Scale Forest Economics, Management and Policy 2(1): 63–80.
31. Jagger P. and J. Pender. 2003. The role of trees for sustainable management of less-favored lands: the case of eucalyptus in Ethiopia. Forest Policy and Economics 5(1), 83–95.
32. _____ J. Pender, Berhanu Gebremedhin. 2005. Trading-off environmental sustainability for empowerment and income: Woodlot devolution in northern Ethiopia. World Development 33: 1491–1510.
33. Kidane Woldu. 1998. Natural regeneration of *Juniperus procera* (Hocht.) *In: Eucalyptus globulus* (Labill.) plantation at Entoto Mountain, central Ethiopia. MSc. Thesis, Swedish University of Agricultural Sciences, Sweden.
34. Legesse Negash. 1990. Ethiopia's indigenous forest species and the pervasive effects of deforestation. *SINET Newsletter* 14: 1-6.

35. Legesse Negash. 1993. Investigation on the germination behavior of wild olive seeds and the nursery establishment of the germinants. *SINET:* Ethiopian Journal of Science, 16(2): 71-81.
36. Legesse Negash. 1999. The Tortuous Path Ahead: How Man is destroying his Earth. Dryland Biodiversity Newsletter 3: 9-12.
37. Lisanework Nigatu, A Michelsen. 1993. The effects of leaf extracts of *Cuppressus lusitanica* and three *Eucalyptus* spp. on four Ethiopian crops. Agroforestry Systems 21, 63-74.
38. Lisanework Nigatu, A Michelsen. 1994. Litterfall and nutrient release by decomposition in three plantations compared with a natural forest in the Ethiopian highland. Forest Ecology and Management 65: 149-164.
39. Masresha Fetene, Solomon Habtemariam. 1995. Investigation on allelopathic properties of coffee (*Coffea arabica L.*) leaves, pulp and tree canopy soil. SINET: Ethiopian Journal of Science 18: 51-65.
40. Mebrate Mihretu. 1992. The regeneration of *Juniperus procera* in *Eucalyptus globulus* plantations. Forestry Research Centre Newsletter 3(1-3), 2-3.
41. _____, Alemu Gezahegne, Belachew Gizachew. 2004. Early survival and height performance of some Australian species in field trials at Didessa, western Ethiopia. Ethiopian Journal of Natural Resources, Vol.6 No. 2: 253-263.
42. _____, Belachew Gizachew, Mesfin Mulugeta. 2002. Survival and growth performance of some eucalyptus species/provenances in elimination trial at Aman, southwestern Ethiopia. Ethiopian Journal of Natural Resources, Vol. 4 No.1: 97-106.
43. _____, Belay Gebre. 2005. The effect of planting site preparations on the establishment of *Casuarina equisetifolia, Eucalyptus camaldulensis* and *Melia azedarach* in the semi-arid area, at Meki. Ethiopian Journal of Natural Resources, Vol. 7 No.2: 2005.
44. Mehari Alebachew, Hameed Sulaiman and Negussie Retta. The effect and phytoaccumulation of chromium at seedling stage of *Eucalyptus camaldulensis* in Ethiopia. pp. 282 - 296 *In:* Gil, Wubalem, Tolosana, and Lopez, (eds) Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.
45. Michelsen A, N Lisanework, I Friis. 1993. Impacts of tree plantation in the Ethiopian highland on soil fertility, shoot and root growth, nutrient utilization and mycorrhizal colonization. Forest Ecology and Management 61, 299–324.

46. Michelsen A, Lisanework Nigatu, I Friis, N Holst. 1996. Comparison of understorey vegetation and soil fertility in plantations and adjacent forests in the Ethiopian highlands. Journal of Applied Ecology 33, 627-642.
47. Mishak O. Melo. Eucalyptus policies in estern Africa: a result of shifting scientific stand. pp 388 -394. *In:* Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.
48. Mulugeta Lemenih, F Bongers. 2010. The role of plantation forests in fostering ecological restoration: experiences form east Africa. *In:* Bongers F, Tennigkeit T (eds). Degraded forests in Eastern Africa: management and restoration. Earthscan Publ. pp. 171-220.
49. _____, Demel Teketay. 2004. Restoration of native forest flora in the degraded highlands of Ethiopia: Constraints and opportunities. SINET: Ethiopian Journal of Science. 27: 75-90.
50. _____, Demel Teketay. 2005. Effect of prior land use on the recolonization of native plants under plantation forests in Ethiopia. *Forest Ecology and Management. 218: 60–73.*
51. Pohjonen V. 1989. Establishment of fuel wood plantations in Ethiopia. Silva Cerelica 14, 1-388.
52. _____, T Pukkala. 1988. Profitability of establishing *Eucalyptus globulus* plantation in the Central Highlands of Ethiopia. Silva Fennica 22 (4), 307-321.
53. _____, T Pukkala. 1990. *Eucalyptus globulus* in Ethiopian forestry. Forest Ecology and Management 36, 19-31.
54. _____, T Pukkala. 1991. Which Eucalypt grows best in Ethiopian Highlands? Journal of Biomass and Bioenergy 1 (4) 193-195.
55. Selamyihun Kidanu, Tekalign Mamo, L Stroosnijder. 2005. Biomass production of *Eucalyptus* boundary plantations and their effect on crop productivity on Ethiopian highland Vertisols. Agroforestry Forum 63: 281–290
56. Shiferaw Alem, Tadesse Woldemariam. 2010. Regeneration of *Coffea arabica* and quality of coffee found in an *Eucalyptus grandis* plantation pp. 122 – 130. In: Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.
57. Sisay Feleke. 2010. Essential oil yield from leaves of *Eucalyptus grandis and Eucalpyus saligna* and their commercial applications. pp. 62 – 67. *In*: Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.

58. Tesfaye Hunde. 1999. Effect of different site preparation methods on growth and survival of *Eucalyptus globulus* Labill at Gefersa, Ethiopia. Ethiopian Journal of Natural Resources, Vol.1 No. 2: 251-258.
59. _____, and Belachew Gizachew, Chris Harwood. 2007. Genetic variation in survival and growth of *Eucalyptus globulus* ssp. globulus in Ethiopia. Australian Forestry 2007, Vol. 70, No.1, pp 48-52.
60. Tesfaye Teshome. 2009. Is *Eucalyptus* Ecologically Hazardous Tree Species? Ethiopian Journal for Research and Innovation Foresight 1(1): 128-134.
61. Tesgaye Tadesse. 2008. The value of some forest ecosystem services in Ethiopia. *In:* Tibebwa Heckett and Negusu Aklilu (eds). Proceedings of Ethiopian Forestry at Crossroads: The Need for a Strong Institution, September 2008, Forum for Environment, Addis Ababa, pp. 83-98.
62. Von Breitenback F. 1961. Exotic trees in Ethiopia. Ethiopian Forestry Review 2: 19-38
63. Woody Biomass Inventory and Strategic Planning Project. 2002. Forest resource of Ethiopia; a sustainable plan for the Sustainable Development, Conservation and Management of the Woody Biomass Resources. Ministry of Natural Resources Development and Environmental Protection. Addis Ababa, Ethiopia.
64. Wubalem Tadesse, Shiferaw Alem, Paula Guzman, Rosana Lopez, Yonas Yohannes and Luis Gil. 2010. Rehabilitation of regarded lands through participatory tree planting in Wayu and Anger Mewagia Kebele, northern Shewa, Ethiopia. pp 114 - 121. *In:* Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.
65. Yirdaw E, O Luukkanen. 2003. Indigenous woody species diversity in *Eucalyptus globulus* Labill. ssp. *globulus* plantations in the Ethiopian highlands. Biodiversity and Conservation 12: 567–582.
66. Yitebitu Moges. 1998. The role of exotic plantation forests in fostering regeneration of native trees in an afromontane forest area in Ethiopia. Thesis, Wageningen Agricultural University. pp. 52
67. Yitebitu Moges. 2010, Eucalyptus trees and the environment: A new perspective in times of climate change. 104 -103. *In:* Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.

68. Yonas Yemshaw. 2002. Over view of forest policy and strategy issues in Ethiopia. *In:* Demel Teketay & Yonas Yemshaw (eds). Forests and Environment, Proceedings of the Fourth Annual Conference of Forestry Society of Ethiopia, 14-15 January 2002. Forestry Society of Ethiopia. Addis Ababa. pp. 8-15.
69. Yoseph Melka Tsegaye Bekele, Jürgen Bauhu. 2010. Factors influencing leaf oil yield of Eucalyptus and Corymbia species growing in Ethiopia. pp. 68-80. *In:* Gil, Wubalem, Tolosana, and Lopez (eds). Eucaluptus Species Management, History, Status and Trends in Ethiopia. 409 pp.
70. Zewdu Eshetu. 2002. Historical C_3 and C_4 vegetation pattern on forested mountain slopes: Its implication for ecological rehabilitation of degraded highlands of Ethiopia by afforestation. Journal of Tropical Ecology 18: 743-758.

The book attempts to clarify the myth, reality, risks, and opportunities that surround the continued "curse-blessing" debate on eucalyptus based empirical evidence but with little technical jargon as possible. Hence, it presents both side of the argument to minimize the drawbacks and maximize the benefits from the species. To this end, several issues on the sound and efficient management with little adverse impact on ecology and/or agriculture are elaborated for its sustained utilization. This is hoped to help policy makers and users make informed decisions.

Professor Mesfin Abebe has written extensively in the field of soil science and the environment. His involvement in agriculture, natural resources, and the environment in different ministries, higher learning and research institutions has offered him a closer look into the forestry sector as reflected in this modest work.

Dr. Wubalem Tadesse has published his studies in several reputed journals for greater visibility of the forestry sector. In addition to his leadership in forestry research, he has been forefront in the organization of many conferences and the edition of the proceedings. Such knowledge and experience has been valuable in the preparation of this publication on eucalyptus in Ethiopia.