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REVIEW ARTICLE

MAJOR DRIVERS AND CONSEQUENCES OF DEFORESTATION IN ETHIOPIA: IMPLICATIONS FOR FOREST CONSERVATION

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ABSTRACT

This review highlights the major drivers and consequences of deforestation in Ethiopia and the forest conservation options. Ethiopia possesses diverse forest resources, which is attributed to its topographic, edaphic and climatic diversity. The forest resources have immense environmental and socio-economic values and thereby play a great role in the sustainable development of the country. However, the forest resources of Ethiopia are dwindling at an alarming rate due to natural and more importantly anthropogenic factors. The major drivers of deforestation and forest degradation are agricultural expansion, overexploitation, urbanization, fire incidence, exotic species and villagization/resettlement, which are all driven by human population growth. There are a number of challenges/problems/ constraints that are limiting the effectiveness of conservation and management of forest resources. Deforestation has led to soil erosion and decline in soil fertility, loss of or decline in biodiversity, shortage of wood and non-wood forest products, reduction in agricultural production and productivity, recurrent drought and famine, flooding, scarcity of water, loss or degradation of wetlands, siltation of water bodies, desertification, climate change, and poverty. Therefore, greater and concerted efforts are needed to reduce deforestation and environmental degradation and thereby ensure environmental stability and human wellbeing in Ethiopia.

INTRODUCTION

Ethiopia is located in the Horn of Africa, stretching from 3-15° N and 33-48° E and covering a total land area of 1.13 million km^2. Ethiopia has great geographical diversity, and is mostly mountainous. There are high and rugged mountains, flat-topped plateaus, slopes, undulating hills, deep valleys and rolling plains. The altitude of Ethiopia ranges from 125 meters below sea level at the Danakil/Afar Depression (the lowest point) to 4,620 meters above sea level at Mt. Ras Dashen/Dejen (the highest peak). The climate varies greatly from hot and arid in the lowlands to cool and temperate in the highlands. The mean annual temperature is from 17-29°C in the lowlands and 11-20°C in the highlands. The mean annual rainfall is 1,400 – 2,500 mm in the south and west, 1,050 – 1,200 mm in the central highlands, 400 – 2,000 mm in the southeast and 350-700 mm in the north (Teketay, 1999, 2004).

Ethiopia is endowed with rich biodiversity and endemism, which is attributed to its topographic, edaphic and climatic diversity. Diverse terrestrial and inland aquatic ecosystems exist in the country. In addition to the great diversity in natural ecosystems, there is a very high diversity of human-influenced ecosystems, particularly agro ecosystems. All these ecosystems are inhabited by a great diversity of plants, animals and microorganisms. Ethiopia and Eritrea possess about 6,027 vascular plant species (including subspecies), of which about 10.74% are endemic (Kelbessa and Demissew, 2014). Likewise, Ethiopia possesses 284 species of mammals, 862 species of birds, 201 species of reptiles, 64 species of amphibians and 200 species of fishes, of which 11.2%, 3.3%, 4.5%, 40.6% and 2.7%, respectively, are endemic. Indeed, Ethiopia is recognized internationally as one of the major centres of biodiversity and endemism (Edwards and Kelbessa, 1999; Yemshaw, 2002, 2004). It is also encompassed by two of the 34 global biodiversity hotspots (Eastern Afromontane Biodiversity Hotspot and Horn of Africa Biodiversity Hotspot). Ethiopia's vegetation types are highly diverse, varying from deserts to tropical woodlands and rainforests to Afroalpine vegetation.

It is believed that about 35% of the total land area of Ethiopia was covered with natural high forests a century ago (EFAP, 1994; Reusing, 1998). However, the forest cover is declining from time to time. The forest cover of the country was 16% in the early 1950s, 3.6% in the early 1980s and 2.7% in 1989

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(EFAP, 1994). The present forest cover of Ethiopia is 4% (Earth Trends, 2007). On the other hand, there are published reports that indicate the current forest cover to be more than this, for instance, 11.9% (Yemshaw *et al.*, 2009). At present, however, reliable estimates of forest cover of the country are lacking. In collaboration with the Food and Agriculture Organization of the United Nations (FAO), the Ministry of Environment, Forest and Climate Change (MoEFCC) is conducting a National Forest Inventory (NFI) since 2014, and the information will be released upon completion. Most of the remaining natural forests of Ethiopia are found in the southern and southwestern parts of the country. Forests have virtually disappeared from the rest of the country, except a few scattered and relatively small areas of forest cover that have remained in the northern, central and eastern parts of the country. These small remnant patches of forests are mostly confined to inaccessible areas (mountaintops, steep slopes, valleys) and sacred places (churches, monasteries, mosques).

Ethiopia's forest resources have immense environmental and socio-economic values. The forests are home to the country's vast plant, animal and microbial genetic resources. They provide tremendous ecosystem services (erosion control, regulation of hydrological cycle, drought and flood mitigation, watershed protection, carbon sequestration, climate regulation, pest and disease control, pollution control, etc.). They also provide various wood and non-wood forest products (fuelwood, charcoal, construction material, timber, poles, posts, agricultural implements, carvings, food, medicines, fodder, fibers, oils, spices, incense, gums, resins, tannins, dyes, honey and beewax, etc.).

The forest resources play a great role in the sustainable development of the country. They significantly contribute to the livelihoods of local communities and the national economy. However, the forest resources of Ethiopia are dwindling at an alarming rate due to natural and anthropogenic factors. The rate of deforestation is very alarming in Ethiopia. The deforestation rate is estimated to be 140,000 – 150,000 ha per year (EFAP, 1994). Ethiopia lost 77% of its forests between 1955 and 1979 (Reusing, 1998). Furthermore, the country lost over 2 million ha of forests between 1990 and 2005 (Yemshaw *et al.*, 2009). Deforestation is one of the biggest challenges for the country. The remaining natural forests of the country could disappear within a few decades unless appropriate and immediate measures are taken.

Major Drivers of Deforestation and Forest Degradation

Drivers of deforestation and forest degradation refer to the human activities that cause loss or degradation of forest resources. In other words, drivers of deforestation and forest degradation are the threats to forest resources. The major drivers of deforestation and forest degradation are agricultural expansion (farmland expansion, overgrazing), overexploitation, urbanization, fire incidence, exotic species and villagization/resettlement, which are all driven by human population growth.

Agricultural expansion

Ethiopia is a country characterized by predominantly agrarian society. Agriculture is the pillar of the Ethiopian economy. Agriculture including forestry accounts for about 85% of the total employment and 90% of the total exports, supplies over 90% of the raw materials to the agro-industries and accounts for 54% of the Gross Domestic Product (GDP) (MoFED, 2006). However, the agricultural production and productivity is low due to deforestation and land degradation; poor agricultural practices; inadequate human, financial and physical resources; and insufficient appropriate agricultural technologies (Wolde Selassie, 1998; Bekele, 1998; Teketay, 2001a; Yemshaw *et al.*, 2009). Agricultural production could not cope with the rapid human population growth.

Forests, woodlands, bushlands, shrublands, grasslands and wetlands are converted to agricultural lands (farmlands, grazing lands) to compensate the deficit in agricultural production. The major factor for the large-scale deforestation in the country is removal of forests and woodlands through clearing and burning to satisfy the growing demand for farmlands and grazing lands. The Ethiopian agriculture has been characterized by extensification rather than intensification (Gebre Egziabher, 1986; Lemenih *et al.*, 2008). Extensification refers to horizontal expansion to new areas whereas intensification refers to improvement of agricultural production and productivity on the existing plots of land using appropriate agricultural methods and inputs.

Because of the need for rapid economic growth, Ethiopia is following the path of aggressive investment, export promotion, import substitution and agro-industry expansion (Yemshaw, 2001). However, the investment is carried out without a prior Environmental Impact Assessment (EIA). The current thrust for more and more investment encourages decision-makers to allocate forests, woodlands and wetlands to agro-industry projects. As such, commercial agriculture is booming at the expense of forests and woodlands.

The moist evergreen Afromontane forests in the southern and southwestern parts of the country (Oromia and Southern Nations, Nationalities and People's regions) have attracted the attention of investors in recent years due to their high potential for timber production and growing coffee, tea, rubber and oil palm. These forests are being destroyed due to uncontrolled exploitation for timber and expansion of coffee, tea, rubber and oil palm plantations. Likewise, Gambella and Benishangul Gumuz regions have become focal areas for commercial farms. Large stretches of land (forests, woodlands) have been leased to investors to grow rice, sugar and oil palm. In many cases, investors have made huge profits at the initial phase of the investment by selling timber and other forest products from forest clearing and leaving the areas without any tax payment or implementation of their proposed projects. This will lead to devastation of the natural ecosystems unless appropriate and immediate measures are taken. Hence, the government needs to revise its program and show political commitment to preserve natural resources in general and forest resources in particular.

Overexploitation

In Ethiopia, forests are excessively exploited for various products (fuelwood, charcoal, construction material, timber, farm implements, food, medicines, fodder, etc.). The high dependence on forests for wood and non-wood forest products has led to large-scale deforestation. Overexploitation is the major threat to the remaining forests and woodlands of Ethiopia.

In fact, the demand for forest products has increased with human population growth. The existing production capacity of the remaining forests is small while the demand for forest products is tremendous (Yemshaw, 2001). The present demand for forest products is many times over the supply and the gap between demand and supply is widening enormously. Ethiopia is facing the problem of wood deficit (i.e. demand exceeds supply).

Ethiopia's fuel wood consumption is estimated to be 84 million m^3 per year (FAO, 2001). A projection made for the year 2020 indicates that the demand for fuel wood will reach over 100 million m^3, against a supply projection of 7.7 million m^3 under a no-intervention scenario (Lemenih, 2009). Thus, the country will face chronic shortage of fuel wood. Rural electrification is a viable option, but it is not achievable within a short period of time. As such, wood will continue to be the dominant energy source for the majority of the rural households.

Urbanization

One of the major factors responsible for deterioration of the rural environment and devegetation of Ethiopia is the growth of towns (Gebre Egziabher, 1986). It is not only human population increase but also population dislocation that have led to loss of vegetation in Ethiopia. An important consequence of urbanization is the increased demand on food production to feed the urban population. The need to produce more on the land to feed people in towns and to export has disrupted the rural system. In addition, the demand for fuel wood, charcoal and timber by urban dwellers has led to destruction of forests and woodlands. Urban-based wood industries have led to the depletion of forest and tree resources of the country.

Ethiopia has one of the largest urbanization rates (4-5%) in the world and its urban population is expected to increase from 15% in 2000 to almost 30% in 2030 (Horst, 2006). Nowadays, the capital Addis Ababa and many towns (e.g. Bahir Dar, Adama, Hawassa) are booming. In most cases, development of infrastructure is at the expense of natural areas. Expansion of Addis Ababa has led to the loss of natural areas in its suburbs, particularly the Entoto Mountains. In the Lake Tana area, the rapid growth of Bahir Dar town and agricultural expansion in the vicinity have led to the decline of about 14 species of trees and shrubs which have their global northern distribution limit in this area (Edwards and Kelbessa, 1999).

Urban and peri-urban forestry will have to become an integral and important part of urban greening activities. It helps to relieve the pressure on natural forests. Green infrastructures provide environmental, social and economic benefits, and thus should get due attention in urban planning in Ethiopia. Development of smart green cities has become the global agenda, and should be so in Ethiopia.

Fire incidence

Forest fire is among the main causes of loss of natural forests in Ethiopia. In fact, forest fire is one of the major factors for the ruthless destruction of forest resources in the country not only in the historical past, for example, during the reign of Queen Yodit or Gudit (842-890 EC) and invasion by Gragn Mohammed (1520-1535 EC), but also at the present. The devastating forest fire that occurred in 2000 in Bale, Borana, East and West Hararghe, North Omo, Ziqualla and other areas destroyed over 150,000 ha of natural forests (Teketay, 2001b). The forest fire that occurred in 2008 at Asebot forest damaged over 12,700 ha of the remnant dry evergreen Afromontane forest (Worku and Zewde, 2009). The forest fire that occurred in different places has also caused a huge damage on beehives, wildlife, soil, crops, livestock and houses. The disappearance of the highland and lowland natural vegetation as a result of intermittent fires is one of the major problems in the country.

Forest fire is either natural or anthropogenic. Natural forest fire is known to happen due to lightning, friction between branches of trees during extended drought, and volcanic activity. However, the major causes of forest fire are anthropogenic (Teketay, 2001b). The major causes of humanmade forest fire are farmland expansion; acquisition of new growth for livestock grazing; logging; charcoal making in the forest; honey collection; cigarette smoking; cooking/roasting in the forest; hunting; creating and maintaining access to the forest; and getting rid of weeds, insects, worms and wild animals (Teketay, 2001b; Wolde Selassie and Gurmu, 2001; Worku and Zewde, 2009; Belayneh and Yohanes, 2009; Gebre Meskel and Tilahun, 2009). Woodlands and grasslands in the lowlands and *Erica* vegetation in the high mountains are regularly burnt to improve pasture. Furthermore, absence of land tenure system, lack of forest ownership and use rights, social conflict, settlement and competition for forestland are predominant causes of forest fire.

The lack of forest fire management policy for preventing and controlling forest fire has been the biggest problem in Ethiopia (Wolde Selassie and Gurmu, 2001). The management of forest fire in Ethiopia has been poorly organized and uncoordinated both at federal and regional levels (Teketay, 2001b). There is neither any formal unit or body specifically responsible for forest fire management nor an efficient and effective system that could coordinate fire management efforts or initiatives among any of the different administrative levels. The management of forest fire is only activated when there are emergency fire outbreaks, and this is done mainly through the mobilization of the local communities. There is no any efficient preparedness and concerned institution or structure with respect to forest fire management even at the federal level. The factors that contribute for the weak forest fire management system in Ethiopia are the lack of appropriate land use and forest policies and legislations; lack of benefit-sharing mechanisms for the local people; lack of organized system for preventing and controlling forest fire; lack of knowledge and skills for fire prevention and control; lack of appropriate fire prevention and control measures; inadequate manpower, budget and facilities; lack of forest fire information system; and lack of awareness about forest fire (Teketay, 2001b).

Therefore, it is important to develop policies, strategies and guidelines to combat forest fire in order to save the remaining natural forests of the country.

Exotic species

The alarming rate of deforestation, the decimation of native tree species, land degradation and the increased demand for

forest products, particularly fuelwood and construction material, have led to the introduction of fast growing exotic tree species to Ethiopia. *Eucalyptus* was first introduced to Ethiopia from Australia during the reign of Emperor Menelik II (1868-1907) to overcome the wood deficit in the country, especially Addis Ababa. Other introduced species include some species of *Pinus*, *Cupressus* and *Acacia*.

Eucalyptus has undesirable ecological qualities which include depletion of soil water and nutrients, production of allelopathic chemicals that suppress the growth of other vegetation, unsuitability for erosion control and incapability of supporting forest-dependent fauna (Negash, 1999). On the other hand, *Eucalyptus* has multiple environmental and socio-economic benefits (Teketay, 2000; Zegeye, 2010). It is very important economically for the farmers because of its many uses and high market value. Moreover, it is the introduction of *Eucalyptus* to this country that partly contributed to the existence of the remaining natural forests and tree species of Ethiopia (Negash, 1999; Zegeye, 2010). This being the reality, there are arguments for and against *Eucalyptus* planting in Ethiopia (Davidson, 1989; Teketay, 2000; Zegeye, 2010). Applying appropriate silviculture and management on *Eucalyptus* planting will enhance the utilization of this important tree for maintaining and/or restoring the environment and solving socio-economic problems in Ethiopia and elsewhere (Zegeye, 2010). Denying *Eucalyptus* is denying the community and that should not be the case. Moreover, *Eucalyptus* is very important for mitigating climate change since it is fast growing and can fix more CO_2 by the process of photosynthesis, thereby serving as a carbon sink.

Exotic species have adverse impacts on native species. They compete aggressively for local resources and affect the growth and reproduction of native species. Exotic species may also become invasive and disrupt the functioning of ecosystems. Why exotic species become invasive? This is because they might not have natural enemies (e.g. competitors, predators, herbivores, pests and diseases) in the new environments. Conversely, native species may not have evolved defence mechanisms against the invaders or they cannot compete with species that have no natural controls. Moreover, the abundance of ecological resources and disturbance regimes in the new habitats as well as climate change may favour invasive species.

Invasive alien species are becoming threats to biodiversity of the country (Tadesse, 2001; Berhanu and Tesfaye, 2006). The major invasive alien species are *Parthenium hysterophorus*, *Prosopis juliflora*, *Opuntia ficus-indica*, *Lantana camara* and *Eichornia crassipes*. *P. hysterophorus* was introduced with aid food, *P. juliflora* for agroforestry purpose, *O. ficus-indica* for edible fruits and animal feed purpose and *L. camara* for ornamental purpose, but the route of introduction of *E. crassipes* is not clearly known. However, these exotic species are now spreading to natural habitats (forests, woodlands, bushlands, shrublands, grasslands, wetlands, water bodies), agricultural lands (farmlands, grazing lands) and urban areas. *P. hysterophorus* is invading farmlands and grazing lands and natural habitats in the eastern, northern, central, southern and southwestern parts of the country, particularly Afar, Hararghe, Borana, Shewa, Wollo and South Tigray. *P. juliflora*, a notorious invasive alien species, is invading natural habitats and farmlands and grazing lands in the northeastern parts of the country. It has already invaded most areas of Afar and is becoming more challenging. It is forming dense and impenetrable stands in some areas. The problem has been realized and there are efforts to use the plant for charcoal and animal feed cake (pods are collected, ground into flour and used to make a flat bread). *O. ficus-indica* is invading natural habitats in dry parts of the country, for example, in Tigray. *L. camara* is invading natural habitats, agricultural lands and urban areas in many parts of the country. It is becoming a problem in some areas like Adama and Bishoftu. It is forming dense stands. *E. crassipes* is invading natural habitats along the Awash River including Koka Dam; along Baro, Gilo, Pibor and Sobate Rivers in Gambella; and very recently northern and northeastern shorelines and water surface of Lake Tana and northern shorelines and water surface of Lake Ziway. In Lake Tana, this notorious weed is posing a threat to biodiversity, tourism and livelihoods of local communities.

Invasive alien species have significant impacts on the environment, economy and health. They reduce the abundance and diversity of native species, disrupt the functioning of ecosystems, reduce crop and livestock production, and cause health problems in humans as well as livestock. Thus, appropriate and immediate measures are needed to control the spread of invasive alien species and minimize their negative impacts. Physical/mechanical, chemical, biological and cultural control methods have been tried so far. However, it should be noted that chemical control, though considered effective, is not recommended from the environmental pollution point of view. Here it should be noted that some native species have also become invasive (spreading rapidly into previously unoccupied habitats) in some areas of the country, for example, in Borana. Native species such as *Acacia drepanolobium, A. mellifera, A. bussei, A. reficiens, A. oerfota, Euphorbia* spp. (e.g. *E. nubia*), *Commiphora* spp. and *Sansevieria ehrenbergii* are invading the rangelands in Borana areas, and thus threatening the local biodiversity and economy, particularly livestock production (Angassa, 2012).

Villagization/resettlement

In Ethiopia, the destruction of forest resources is partly associated with population growth and migration. Population growth and migration increase the pressure on forests, as more land is cleared for agriculture to meet the demand for food and trees are cut for fuelwood, house construction, farm implements and other purposes. Inappropriately planned development patterns exacerbate the pressure on forests, as people are made to migrate into less productive and ecologically more fragile areas. Forced villagization programmes during the Dergue regime and voluntary villagization programmes that are undertaken by the present government, as a strategy for tackling the problem of food insecurity and land degradation, have contributed much to the loss or degradation of vegetation resources. At present, villagization programmes are undertaken in the different regions (Tigray, Amhara, Afar, Somali, Oromia, SNNPR, Gambella, Benishangul Gumuz). Between 2000 and 2004, about 400,000 household heads or 2.2 million people have been formally resettled in Tigray, Amhara, Oromia and SNNPR (Lemenih, 2011).

New settlements in primary forests are becoming commonplace and hence have resulted in the conversion of

forests to agriculture and other land uses, subsequently causing forest fragmentation (Bekele, 2008). For instance, the conversion of Sheko forest in southwestern Ethiopia to other land uses is increasing at an alarming rate mainly due to the arrival of new settlers from other parts of the country (Senbeta *et al.*, 2007). Furthermore, population migration causes competition for resources between natives and migrants, and the conflict in turn results in forest destruction. For example, the forest fire incidence in 2000 in the Bale and Borana Zones is partly associated with social conflict between natives and new settlers from other areas, competition for forestland and lack of benefit-sharing.

In recent years, resettlement programme is widely practiced and most of the resettlement practices, which are Region-based, are mainly affecting the lowlands where the remaining dry forests of the country are situated (Lemenih and Mekonnen, 2011). Studies from different dry forest areas that hosted resettlement have shown that there is significant degradation of forests. In Metema District, for instance, cropland expanded from 30,725 ha in 1972 to 95,659 ha in 2007, which is approximately 1,855.3 ha per year (Emrie and Tarekegn, 2010). Estimates showed that nearly 303,180 ha of forests in the District have been converted to agricultural lands in just 30-35 years (Lemenih and Mekonnen, 2011). In Pawe District, agricultural land/settlement increased by 6,876.5 ha (18.3%) and bare lands and grasslands by 659.6 ha (1.78%) and 8,956.3 ha (23.8%), respectively, in just 15 years, while bamboo forest and thicket of 18,365.8 ha were lost following (re)settlement during the same period (Kebede, 2006). In Borana of southern Ethiopia, between 1987 and 2003 cultivated land increased by 72.5% and settlements by 79.8% (Abate and Angassa, 2016).

Villagization is not a viable option. It has environmental, social, economic, cultural and political impacts. In general, rehabilitation and development in the area where the people have lived since a long time is a much better option than displacement/abandonment in the form of the so-called villagization programmes. On the other hand, when resettlement is a necessity due to natural disasters (e.g. volcanic eruptions, earthquakes) or for the sake of strict nature conservation (e.g. Semien Mountains National Park) and influential development (e.g. construction of big dams), it should be well planned. In such cases, there is a need to provide a reasonable amount of compensation payment and the necessary technical support to the resettlers.

Factors Limiting the Effectiveness of Conservation and Management of Forest Resources

A number of factors (challenges/problems/constraints) have limited and continue to limit the effectiveness of conservation and management of forest resources of Ethiopia. The major factors that are limiting the effectiveness of conservation and management of forest resources are:

- Human population growth (currently about 104 million), which is the major driving force for many environmental and socio-economic problems;
- Lack of appropriate land use, forest and investment policies and legislations;
- Institutional instability of the forestry sector;
- Inequity in resources ownership and utilization;
- Lack of adequate scientific knowledge (e.g. ecology of natural ecosystems, genetic and species diversity, reproductive biology and phenology of species, silviculture and management of natural forests and plantations, propagation techniques of indigenous tree and shrub species);
- Lack of adequate human, financial and physical resources;
- Poor collaboration among higher learning institutions and research institutions;
- Reluctance on the dissemination and application of forestry research findings.

Grave Consequences of Deforestation

Deforestation and environmental degradation have put humanity at the risk of survival across the world, and hence Ethiopia is not an exception. In Ethiopia, deforestation has resulted in multifaceted adverse consequences. Massive soil erosion and hence soil nutrient depletion have occurred in Ethiopia due to the decimation of its natural forests (Negash, 1995, 2002). Deforestation has led to soil erosion and decline in soil fertility, loss of or decline in biodiversity, shortage of wood and non-wood forest products, reduction in agricultural production and productivity, recurrent drought and famine, flooding, scarcity of water, loss or degradation of wetlands, siltation of water bodies, desertification, climate change, and poverty (Gebre Egziabher, 1986; Nigatu, 1987; EFAP, 1994; Bishaw, 2001; Teketay, 2004; Yemshaw *et al.*, 2009; Tadesse *et al.*, 2011, 2012). Hence, deforestation has led to environmental, social and economic problems in Ethiopia. This calls for appropriate and immediate interventions so as to maintain the biodiversity in general and forest resources in particular.

Depletion of trees and shrubs

Depletion of forest resources is very alarming in Ethiopia. Felling trees and shrubs for fuelwood, charcoal, construction material, timber and farm implements has resulted in the depletion of many woody species. Certain woody species have declined in numbers of individuals or disappeared altogether in some locations. *Juniperus procera, Podocarpus falcatus, Hagenia abyssinica*, *Cordia africana*, *Olea europaea* subsp. *cuspidata, Prunus africana* and *Combretum molle,* formerly the commonest high-altitude forest trees in Ethiopia, are nowadays reduced to scattered individuals in mountain areas due to overexploitation for fuelwood, charcoal, construction material, timber, farm implements and other purposes. The bark, flowers and roots of *Hagenia abyssinica* are highly valued for medicinal purposes – used as a drug to treat intestinal parasites. Other useful trees and shrubs that are under threat in the wild include *Erythrina burana*, *Moringa rivae* subsp. *longisiliqua* (used as food), *Senecio myriocephalus*, *Solanecio gigas* (used as hedge plants around household yards), *Boswellia pirottae* (a source of incense and fuelwood) and *Maytenus addat* (used for fuelwood, timber and medicine). The shrub *Taverniera abyssinica*, an important medicinal species, is threatened by collecting. It is sold in urban markets as a cure for fever and stomach cramps. The leguminous shrub *Cordeauxia edulis* used to be common in semi-arid bushlands of Somali region. It is used as fuelwood, construction material, food (both leaves and seeds), fodder, bee forage, soil conservation, live fence and for tannins.

Nowadays it has become rare due to overgrazing and overexploitation.

Dryland forest resources of Ethiopia, which have actual and potential environmental and socio-economic benefits, have been under tremendous pressure from unsustainable utilization, which has resulted in their rapid dwindling or complete disappearance in some areas. Several gum- and resin-bearing species, namely some species of *Acacia*, *Boswellia* and *Commiphora*, are endangered (Gebrehiwot *et al.*, 2003; Eshete *et al.*, 2005; Vivero *et al.*, 2005; Worku, 2006; Yebeyin, 2006). Several bamboo species are endemic to Africa, and Ethiopia is one of the countries with the largest stock of two indigenous bamboo species, namely lowland bamboo (*Oxytenanthera abyssinica*) and highland bamboo *(Arundinaria alpina*). However, bamboo resources of Ethiopia have been depleted in recent years due to (re)settlement, farmland expansion, unsustainable utilization and fire incidence.

Soil erosion and reduction in agricultural production and productivity

Ethiopia is facing serious environmental problems, particularly deforestation and land degradation. Deforestation is one of the major factors contributing to land degradation by exposing the soil to water and wind erosion. Being mostly mountainous, Ethiopia is highly susceptible to soil erosion. It is estimated that the country loses 1.9 to 3.5 billion tons of soil each year (EARO, 2000). With the estimated soil erosion rate of 100 tons per ha per year, soil erosion in Ethiopia causes the irretrievable loss of 1.17 to 7.8 million tons of soil organic matter, 0.39 to 5.07 million tons of soil nitrogen and 1.17 to 11.7 million tons of phosphorus per year (Lemenih, 2004). Agricultural expansion is causing more and more soil and nutrient loss. Indeed, soil loss is greatest on cultivated lands compared to that on pastures and forests. Furthermore, crop residues and animal dung are increasingly used as household fuel instead of serving as natural fertilizers for the soil, thereby reducing the soil fertility and depressing agricultural yields. Ethiopia is suffering from increasingly severe soil erosion and reduced soil fertility. The loss of soil and the deterioration in soil fertility, moisture storage capacity and structure of the remaining soils, all reduce the country's agricultural production and productivity. This calls for intensification of agriculture, i.e. increasing agricultural production and productivity on existing plots of land using appropriate agricultural methods and inputs.

Loss or degradation of wetlands

Ethiopia has numerous wetlands (streams, rivers, lakes, dams, ponds, swamps, etc.). With the exception of coastal and marine-related wetlands, all forms of wetlands are represented in Ethiopia. However, many wetlands are facing serious ecological problems due to deleterious anthropogenic activities in the catchment areas. Clearing of forests, construction of irrigation and drainage systems, building of factories and use of fertilizers and pesticides, all contribute towards the damage of these indispensable but fragile systems (Woldu, 2003). Deforestation and overgrazing in the watersheds; siltation; overfishing; increased use of water for domestic, agricultural and industrial purposes; discharge of municipal and industrial wastes (pollution); invasive alien species; and climate change, are all threatening wetlands. Deforestation, siltation and climate change have led to significant reduction in water level (volume and surface area) to complete drying up of many streams, rivers and ponds as well as lakes. Many lakes such as Tana, Ziway, Langano, Abijata and Chamo are shrinking in water level (but some lakes like Metehara/Beseka and Hawassa are increasing in water level), and a few lakes have already dried up. Drying up of Lake Haramaya (formerly Lake Alemaya) is a very recent history. Loss or degradation of wetlands will result in scarcity of water, loss of wetland biodiversity and associated livelihoods, and disruption of ecological systems in the area and beyond.

Siltation of water bodies

Deforestation and overgrazing in the watersheds, compounded with poor agricultural practices, have led to reduced infiltration of rainwater and increased runoff and sedimentation of water bodies (especially lakes and dams), thereby reducing the quantity and quality of water for domestic and industrial uses, hydroelectric power generation, irrigation, livestock and fish production, transportation and recreation. Many lakes are facing the problem of sedimentation and hence reduction in water level. Hydroelecric power dams such as Koka Dam, potable water supply dams such as Legedadi Reservoir, and irrigation dams such as Borkana Dam (northeastern Ethiopia) and Gode Dam (eastern Ethiopia), all have been affected by siltation (Elias, 2003; Tefera, 2006; Tadesse, 2009; Tamene *et al.*, 2011). Siltation of Koka Dam has adversely affected the supply of energy in the country. Recently constructed hydroelectric power dams such as Tekeze Dam and Gilgel Ghibe I Dam are also facing the problem of siltation due to deforestation and soil erosion in the catchment areas. This calls for curbing deforestation and promoting tree planting and soil and water conservation in the watersheds so as to halt environmental degradation and siltation of water bodies.

Climate change

Carbon dioxide (CO_2) is one of the major Greenhouse Gases (GHGs). It is known that plants remove CO_2 from the atmosphere during the process of photosynthesis and release it back during respiration. However, deforestation affects this balance. Tropical deforestation accounts for approximately 20% of the global GHG emissions. Thus, deforestation is a strong contributor to climate change. Climate change has adverse impacts across the world. However, Africa is the most vulnerable to the impacts of climate change mainly due to the high dependence of its people on natural resources for their livelihoods and widespread poverty (IPCC, 2007; Chidumayo *et al.*, 2011). As such, Ethiopia is the most vulnerable to the impacts of climate change with the least capacity to respond.

Ethiopia's climate is naturally both highly diverse and highly variable. However, the climate is changing dramatically in recent years. In the last 50 years, the annual average maximum and minimum temperatures of the country have been increasing every decade by about 1^oC and 0.25^oC, respectively (NMSA, 2001). The mean annual temperature for the period 1960-2006 increased by 1.3^oC, 0.28^oC per decade (McSweeney *et al.*, 2008). Rainfall shortage and variability is also increasing. Climate change is also perceived by local people (Deressa *et al.*, 2008). Climate change has led to

recurrent drought and famine, flooding, reduction in agricultural (crop and livestock) production, scarcity of water, desertification, loss of wetlands (e.g. Lake Haramaya), spread of invasive alien species (e.g. *Parthenium hysterophorus*, *Prosopis juliflora, Lantana camara*), hampered forest regeneration and spread of malaria into highland areas. Most of the dryland ecosystems, particularly those in Afar, Somali, Borana and South Omo, are vulnerable to desertification. Dieback of *Juniperus procera* and *Olea europaea* subsp. *cuspidata* has occurred in Desa'a forest in northern Ethiopia due to climate change (Aynekulu *et al.*, 2011). Climate change is likely to aggravate land degradation, desertification, loss of water bodies, loss of forest regeneration, food insecurity, and poverty in Ethiopia.

Socio-economic impacts (poverty)

Drastic shortage of forest products and income that could be derived from selling forest products are all related to the economic impact of deforestation in Ethiopia. Deforestation has led to depressed livelihoods. The other major impact of deforestation is weakening of the supporting role of the forestry sector to other sectors like crop and livestock production, which is very critical. Unsustainable use of the forest resources significantly reduces the contribution of forestry to the local and national economy. Deforestation puts forest coffee at risk. If the forests disappear, the coffee gene pool also disappears. Forests are assets that depreciate when misused. Using depreciation approach, conservative estimates showed that nearly one-third of forestry's contribution to the GDP is lost each year due to depletion of forest resources (deforestation) in Ethiopia (Tadesse *et al.*, 2011). The impact of deforestation in depriving ecotourism in the country cannot be overlooked as many species are threatened while the landscape in many areas lost its aesthetic beauty. Thus, forest depletion or degradation could be a cause of severe poverty in several ways (EFAP, 1994).

Conclusion and Recommendation

Ethiopia possesses diverse forest resources, which is attributed to its topographic, edaphic and climatic diversity. The forest resources have immense environmental and socio-economic values and thereby play a great role in the sustainable development of the country. However, the forest resources of Ethiopia are dwindling at an alarming rate due to natural and more importantly anthropogenic factors. The major drivers of deforestation and forest degradation are agricultural expansion, overexploitation, urbanization, fire incidence, exotic species and villagization/resettlement, which are all driven by human population growth. The major factors that are limiting the effectiveness of conservation and management of forest resources are human population growth; lack of appropriate land use, forest and investment policies and legislations; institutional instability of the forestry sector; inequity in resources ownership and utilization; lack of adequate human, financial and physical resources; lack of adequate scientific knowledge; poor collaboration among higher learning institutions and research institutions; and reluctance on the dissemination and application of forestry research findings. Deforestation has led to soil erosion and decline in soil fertility, loss of or decline in biodiversity, shortage of wood and non-wood forest products, reduction in agricultural production and productivity, recurrent drought and famine, flooding, scarcity of water, loss or degradation of wetlands, siltation of water bodies, desertification, climate change, and poverty.

Thus, greater and concerted efforts are needed to reduce deforestation and environmental degradation and thereby ensure environmental stability and human wellbeing in Ethiopia.

Therefore, in order to ensure the conservation, development, management and sustainable utilization of the forest resources of Ethiopia, the following recommendations are forwarded:

- Curb human population growth by strengthening family planning services;
- Protect the remaining natural forests;
- Formulate appropriate land use, forest and investment policies and legislations;
- Raise awareness about the conservation and management of forests and other natural resources in the government and the general public;
- Allocate adequate human, financial and physical resources to the forestry sector;
- Strengthen forestry research, education and training;
- Prioritize ecosystems, species and populations for conservation actions;
- Strengthen the management of existing protected areas and promote the establishment of new protected areas in different agroecological zones of the country with provision of the necessary resources (human, financial, technical, institutional, infrastructural);
- Improve agricultural production and productivity using appropriate agricultural technologies and inputs and agricultural extension services;
- Devise appropriate forest fire prevention and control system;
- Support the conservation of church forests;
- Promote tree planting (afforestation, reforestation, agroforestry) and forestry extension services;
- Give high priority to indigenous tree and shrub species in plantation programmes (suitable exotic tree species can be used as deemed necessary);
- Develop appropriate benefit-sharing mechanisms based on the rights and interests of local communities;
- Promote the dissemination and application of forestry research findings;
- Encourage the public and private sectors to be involved in forestry investments;
- Enhance indigenous resource management systems and practices;
- Promote sustainable forest management including participatory forest management;
- Promote the development of renewable energy sources and use of energy-saving stoves;
- Promote the involvement of all relevant stakeholders with proper integration;
- Promote sustainable tourism including ecotourism;
- Strengthen collaboration among institutions concerned with forest conservation at local, national, regional and international levels;
- Exploit emerging global funding opportunities such as forest certification and carbon financing to catalyze the conservation, development and management of the forest resources of the country.

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