FOREST TYPES
in Ethiopia
Status, Potential Contribution and Challenges
Antiaris toxicaria belongs to the family Moraceae. Its local name is "Tangi".

Photo credit
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Antiaris toxicaria belongs to the family Moraceae. Its local name is "Tangi".
"If we take care of the Earth, the Earth will take care of us."

Forum for Environment (FfE)

FOREST TYPES IN ETHIOPIA

STATUS, POTENTIAL CONTRIBUTION AND CHALLENGES

Editors
Ensermu Kelbessa
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Ethiopia is a country of great geographical diversity. Altitudes range from the lowest at the Afar Depression to the highest peak at Ras Dejen. The climate ranges from equatorial desert to hot and cool steppe, and from tropical woodlands and rain forest to warm temperate and cool highland. Although the country is endowed with immense plant wealth of wild, numerous cultivated crops and a large number of medicinal plants, it has not been able to properly utilize these resources sustainably due to various reasons such as lack of awareness, shortage of trained man power (including loss of trained manpower through brain drain), prevailing poverty and others.

The Environmental Policy of Ethiopia, states that the country should promote in-situ and ex-situ systems as the primary target for conserving both wild and domesticated biological diversity; Thus, the policy advocates the need for conservation of plant resources both in-situ and ex-situ. Further, the Conservation Strategy of Ethiopia, also as one of the strategies in forest resource and ecosystem management suggests the promotion of conservation of natural forests and expanding the existing network of protected areas by concentrating efforts on establishing and implementing management plans for forest priority areas; determining which are suitable for habitat protection, conservation and production so that the existing network of protected areas is expanded; endemic and rare species as well as unique ecosystems and watersheds are adequately protected and adequate wood production is carried out on a sustainable basis.

However, despite the availability of policies and strategies, the vegetation of Ethiopia has been over utilized by various destructive forces and agents. The forests and woodlands have been under pressure for different reasons, though population growth and poverty have always been blamed for the destruction. Since the economy of Ethiopia is based on environmental resources, it has to be underlined that the dominant agricultural sector can develop to ensure food security if and only if the environmental resources are protected, conserved and sustainably utilized.

The Food and Agriculture Organization of the United Nations (FAO) Forest Resources Assessments defines ‘forest’ as “land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use” (FAO, 2007). Based on FAO’s definition of a forest, out of the nine major vegetation types of Ethiopia, the following six types can be considered as forests: i) Acacia-Commiphora (Small-leaved Deciduous) Woodland,
ii) Bamboo Tickets, iii) Combretum-Terminalia (Broad-leaved Deciduous) Woodland, iv) Dry Evergreen Montane Forest, v) Moist Montane Forest, and vi) Lowland Semi-Evergreen Tropical Forest. This book deals with each of these types with respect to their status, potential contributions, challenges and recommendations. Summaries of the six papers are presented below.

Acacia-Commiphora forests are mainly found in the southern and Central Rift Valley (CRV) low lying areas with altitudes above 1,000 and below 1,900 m a.s.l. Drought tolerant small-leaved trees and shrubs are the characteristic plant species mostly found in this forest type though there are variations from place to place. These forests are rich with gum and resin producing Acacia, Boswellia and Commiphora species. The pastoralists living around these forest consider it as rangelands for livestock production. These narrow-leaved deciduous forests are also a source of diverse and commercially important non-wood products such as gum arabic, frankincense and myrrh. Gum and resin products are the only source of income for some households residing around production areas while for others it is an alternative means of income during dry seasons in times of shortage of grains and fodder. Additionally, they are also a source of foreign currency as they are exported to more than 40 countries. Acacia-Commiphora narrow-leaved deciduous forests and dry forests in general are faced with a combination of natural and man-made challenges which include: Bush encroachment and invasion of alien species (such as Prosopis juliflora); increased human and livestock population pressure; climatic variability, climate change and chronic food insecurity; land degradation; policy related challenges; agro fuel related development; and weakening of traditional institutions.

Ethiopia has two indigenous bamboo species: the highland bamboo (Arundinaria alpina K.Schum. synonym: Yushania alpina) and the monotypic genus lowland bamboo Oxytenanthera abyssinica (A. Rich.) Munro. Oxytenanthera abyssinica is a clumping (sympodial) type bamboo with “solid” culm at maturing age and is widely distributed in the western lowland areas of the country. About 85% of the total bamboo forest of the country is covered by this species. Arundinaria alpina is a non-clump forming bamboo with hollow culms. About 15% or more than 130,000 ha of the bamboo forest in the country is covered by this species. Arundinaria alpina grows on high mountains, hills, and plains in the form of pure or mixed strands. Highland bamboo stands outside forests, mostly growing on farmsteads, are a major source of raw material for furniture makers. Despite this, there is no sufficient inventory for bamboo stands on farmers homestead. There is lack of reliable information on bamboo resources drawing on an urgent need to establish accurate inventories and to conduct comprehensive data collection.
In Ethiopia, the economic potential of bamboo has not yet been explored and the role of bamboo resources in the national economy is negligible. However, bamboo is important for soil and water conservation; reduction of deforestation and consequently land degradation; as a source of carbon sink; aesthetic value; source of food; construction of traditional houses; making furniture; bamboo-based panel boards and pulp/paper industry. Some of the challenges facing utilization of bamboo resources are: lack of policy on bamboo resources and non-consideration as a high priority resource; poor infrastructure in bamboo growing areas; lack of research on biology, on basic properties and industrial utilization of both bamboo species; burning of bamboo stands, etc.

Combretum-Terminalia broad-leaved deciduous forests occur mainly in the northwestern, western and southwestern parts of the country specifically in Tigray, Amhara, Benishangul Gumuz, Gambella, Oromia and SNNPR. Recent decades have witnessed an unprecedented scale of immigration from highlands to the Combretum-Terminalia broad-leaved deciduous forests through resettlement programme, which continues to cause large scale deforestation and degradation of the "woodlands" into croplands. Additionally, the suitable conditions of the forest for growing crops like sesame and cotton is attracting large scale investors further intensifying the conversion of the ecosystem.

In some parts of Tigray and Amhara regions, Combretum-Terminalia broad-leaved deciduous forests are largely used as grazing sites for livestock of transhumance which are increasing due to feed shortage, expansion of crop cultivation and increasing cattle population in the highlands. Combretum-Terminalia broad-leaved deciduous forests are a source of food (forest foods), fodder, honey, medicinal plants and wood for fuel and construction. The most economically important forest products obtained from the Combretum-Terminalia broad-leaved deciduous forest are perhaps frankincense and gum arabic which are exported. Frankincense production is used as significant income diversification in central Tigray. Challenges to the use and management of Combretum-Terminalia broad-leaved deciduous forests include: clearance for agriculture by both small holders and agri-business investors; over grazing (local plus transhumance), forest fire and excessive harvest of wood for construction and firewood and underlying causes such as population growth mainly due to immigration (resettlement) and policy constraints.

Dry Evergreen Montane Forest is a complex vegetation type occurring in an altitudinal range of 1500-3200(-3400) m a.s.l. with average annual temperature and rainfall of 14-25°C and 700-1100 mm, respectively.
This forest originally occupied a large area in the northern, central, southern and southeastern highlands of Ethiopia but by now it has been considerably depleted and is situated on some isolated highlands and mountain chains such as Desa’a, Yegof, Chilimo, Menagesha-Suba, Wof-Washa, Arero, Yaballo, Asebot, Gara Ades, Gara Mulata, Adaba-Dodolla, Dinsho, Gedo, Ziqualla, etc. The dominant trees in this forest type consists of Juniperus procera, Olea europaea ssp. cuspidata, Podocarpus falcatus, etc. The forest is also rich in other plant and wildlife diversity. It is inhabited by the majority of the Ethiopian population for centuries. As a result, the forests have diminished and replaced by scrublands and farm lands in most areas of the country. The dry evergreen montane forests provide fuel wood, construction materials, farm implements, edible fruits, honey, medicinal plants, grazing area and game for hunting with some tree species acting as a buffer during hardship period and ‘lean seasons’. The forest prevents soil erosion and regulates the watershed in the surroundings and some of the forests are important water catchments for rivers.

Forests regulate water flow and thus increase overall water availability for drinking and irrigation, and protect reservoirs from siltation and sedimentation. Forests are also important for biodiversity conservation which is important storehouse of genetic material and aid in carbon sequestration. As the dry evergreen montane forests are generally inhabited by majority of the Ethiopian population and represent a zone of sedentary cereal-based mixed agriculture, the forest is under severe pressure of destruction due to consistently increasing human habitation surrounding the forest area, poverty and illiteracy among large sections of the population, over-exploitation, site degradation and land conversion. There is also a severe and rising fuel wood scarcity in the country, which puts extra pressure on the remaining natural forest. Another threat to dry evergreen montane forest is the conversion of high forest sites to commercial plantations which cause ecological impacts and loss of biodiversity.

Ethiopian moist montane forests occur within a wide range of annual and seasonal rainfall patterns. They typically form a belt of vegetation over an altitudinal range between 1000(1200) - 2600 m in the southwest of the NW and SE highlands of Ethiopia. The tree canopies are characteristically made up of a mixture of broad-leaved species like Pouteria adolfi-friederici, P. altissima and Olea welwitschii, and Podocarpus falcatus. A part of this forest is considered to be the center of origin and diversity of wild Coffea arabica. The moist montane forests are serving as sources of livelihood by providing coffee, honey, spices, wild food, medicine, farm tools, fuel wood, timber and related products. The fragments of moist montane forests of Ethiopia are the only natural habitat of wild Arabica coffee populations which are important both for national and international coffee breeding programmes.
They are important in watershed management and as water catchments and erosion barriers, including a role in the capture and transport of water and protection of soils against erosion; the moist montane forests of southwest and west Ethiopia also play a significant role in irrigation and hydropower generation. Settlement, expansion of agriculture and logging, and commercial plantations of tea/coffee are transforming montane forests into different land use systems. Land use changes in the montane forest are taking place as a result of timber extraction, coffee and tea plantations development, agricultural expansion, human settlement and sometimes, fire hazards. The presence of huge potential for timber, coffee and tea production in the moist montane forest areas have become very much attractive to various investment endeavours.

The lowland semi-evergreen forest of Ethiopia comprises of a narrow strip of humid forests along the southwestern corner of the country and covers just a small portion of Gambella Regional State. It is usually found between 450-600 m a.s.l. It covers an area of about 200,000 ha and is specifically situated in Abobo, Gog, Godere and Dima districts. Available and complete data on the structure and floristic composition of the forest is lacking and necessitates research to fill this gap. The Ethiopian lowland semi-evergreen forest has a very high level of endemism and harbors many restricted or threatened species. Hence, the lowland semi-evergreen forest of Ethiopia can serve as a gene reserve for many of these useful forest species.

Similar to moist montane forests, the lowland semi-evergreen forest serve as a source of livelihood for the local community through provision of honey (for consumption as well as sale), wild food, medicine, farm tools, fuel wood, furniture and construction materials as well as play a significant role in hydrological and ecological function such as stabilizing water quality, maintaining the natural flow pattern of the streams and rivers as well as supporting various irrigation schemes based on river systems originating or passing through the lowland semi-evergreen forest. Based on its forest cover and global valuation placed for forest service types (such as climate regulation, water regulation, water supply, erosion control and sedimentation retention, soil forms, nutrient cycling, genetic resources, recreational and cultural significance), the annual economic value of the forest is estimated at USD 313,800,000.00. Expansion of settlement, fire, shifting cultivation and commercial plantations are causing continuous deforestation in recent times.
The traditional livelihood system of the local communities living around the forest has changed over time from hunting and gathering to farming which is practised over a large area of the forest. All this coupled with mass migration and increased development activities in the area are posing serious threat to the lowland semi-evergreen forest of Ethiopia.

This document is intended to serve as a reference on the existing forest vegetation types in Ethiopia. We believe the gaps identified with regards to the existing information/knowledge of these forests can give an idea for future researches.

Happy reading!
ACACIA-COMMIPHORA SMALL-LEAVED DECIDUOUS FORESTS OF ETHIOPIA

Mulugeta Lemenih

Introduction

Ethiopia's forest resources are diverse, and comprises vegetation types that range from tropical rain and cloud forests in the southwest and south through dry forests of various complexity in the north, west, south, and central mountains and lowlands to the desert scrubs in the east and north east and parkland agroforestry on the central plateau (Mulugeta Lemenih and Tadesse Woldemariam, 2010). Dry forests, however, share the largest part of the forest resources of Ethiopia and cover some 55 million ha (WBISPP, 2004). The phrase 'dry forests' in this paper is used in a general manner to refer to the different forest types found on the mountains and in drylands of Ethiopia. The dominant dry forest types are Acacia-Commiphora narrow-leaved deciduous forest, lowland bamboo and Combretum-Terminalia broad-leaved deciduous forests.

Dry forests are defined differently in different literature. Various aspects are emphasized in the different definitions. While some emphasize structural complexity such as height, density; others emphasize foliar aspects (deciduous vs. evergreen, small-leaved vs. broad-leaved), canopy cover (open vs. closed) or nature of understory vegetation.

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2Forest resources in this paper refers to the definition provided in forest proclamation no. 547 of Ethiopia issued in 2007 (FDRE, 2007). According to this definition, forest is "a community of plants, either naturally grown or developed by planting and mainly consisting of trees and other plants having woody character". The definition includes a broad range of woody vegetation types from forests of varying complexity with a closed canopy, through woodlands with an open canopy to bushland/shrubland where most of the woody plants are multi-stemmed from the base or near the base.

3Dry forest refers to vegetation resources occurring in frost-free climates from lowlands to lower montane regions where potential evapo-transpiration exceeds precipitation on an annual basis (Holdridge, 1967).
Still others emphasize ecological attributes such as dry forests of more arid environments (eutrophic woodlands) vis-a-vis woodlands of relatively wetter environments (dystrophic woodlands). The previous definition in Ethiopia for woodlands is “land covered with an open stand of trees taller than 5 m and up to 20 m in height and a canopy cover of more than 20%” (EFAP, 1994) which are now considered to be forests with a canopy cover of more than 10% (FAO, 2005). According to this latter definition, woodlands which are now considered to be forests include Acacia-Commiphora narrow-leaved deciduous forest, lowland bamboo forest, Combretum-Terminalia broad-leaved and riverine forests located in these dry forests.

Scholarly categorization of woodland vegetation in Ethiopia overlaps with the classification based on ecological attributes vis-a-vis eutrophic and dystrophic woodlands. Two broad classes of woodlands that have often been identified in Ethiopia are: the Acacia-Commiphora small-leaved deciduous woodlands and the Combretum-Terminalia broad-leaved deciduous woodlands; the former corresponding to the eutrophic woodlands and the latter corresponding to the dystrophic woodlands (Plate 1). This is because the eutrophic woodlands are dominated by the family Fabaceae (mainly Acacia species) and/or Burseraceae (mainly Commiphora species). The most readily identified characteristics of eutrophic woodlands include:

- Occurrence of tree species with relatively small leaves or leaflets;
- Occurrence of thorny species;
- Presence of succulents; and
- Absence of any well-developed litter layer.

Indeed, the Acacia-Commiphora small-leaved deciduous woodlands in Ethiopia correspond with the eutrophic woodland types. They also roughly correspond with the ‘tropical thorn woodland and/or tropical very dry forests’ as per the classification of world vegetation types (Holdridge, 1967) while they fulfill the criteria of forests set out by the Food and Agriculture Organization of the United Nations (FAO, 2005).

On the other hand, dystrophic woodlands are dominated by the family Combretaceae (mainly Combretum and Terminalia species). The most readily identifiable characteristics of dystrophic woodlands are:

- Occurrence of trees species with relatively large leaves or leaflets;
- Relative absence of thorny species;
- Absence of succulents;
- Presence of well-developed litter layer; and
- Low herbaceous biomass.
These classes correspond to the commonly described woodlands in Ethiopia as Combretum-Terminalia broad-leaved vegetation and also roughly correspond with the ‘tropical dry forest’ classification of Holdridge (1967) as well as the definition of a forest as defined by FAO (2005).

In this paper, the emphasis is on the eutrophic woodlands or Acacia-Commiphora forests. The objectives of the paper are to summarize available information on the Acacia-Commiphora small-leaved forest resources of Ethiopia, portray their socio-economic importance, analyze major challenges facing this forest type and finally forward recommendations for improved future management and sustainable utilization. The information presented in this paper is based on extensive literature review blended with long years of teaching and research experiences of the senior author on dry forest resources of Ethiopia.

Plate 1 Typical examples of Acacia-Commiphora small-leaved deciduous forest type (upper two photos) and Combretum-Terminalia broad-leaved deciduous forest (lower two photos) of Ethiopia (Photo: Mulugeta Lemenih)
MAJOR ATTRIBUTES OF THE ACACIA-COMMIPHORA FORESTS

Geographic distribution and species composition

Acacia-Commiphora forests are predominantly found in the southern and Central Rift Valley (CRV) low lying areas with altitudes above 1,000 and below 1,900 m a.s.l. The characteristic plant species in this forest type, although variable from area to area, are mostly drought tolerant small-leaved trees and shrubs. Some of the conspicuous species are *Acacia tortilis*, *A. seyal*, *A. senegal*, *A. etbaica*, *A. sibieriana*, *A. mellifera*, *A. drepanolobium*, *Commiphora africana*, *C. myrrha*, *C. fluviiflor*, *C. habessinica*, *C. paolii*, *C. crenulata*, *C. boranensis*, *C. guidotti*, *C. erythraea*, *C. schimperi*, *C. ogadensis*, *C. rostrata*, *C. serrulata*, *C. gileadensis*, *C. hildebrandti*, *C. erosa*, *C. cyclopallya*, *C. corrugata*, *Boswellia microphylla*, *B. neglecta*, *B. riva*, *Balanites aegyptica*, *Maytenus senegalensis* and *Ziziphus mucronata*.

Species richness varies from site to site. While close to 64 woody species distributed in 23 families and 31 genera have been recorded from Arero and Yabello districts of the Borana narrow-leaved deciduous forest (Table 1), only eight trees and shrub species are recorded from the forests of CRV (Table 2). In most of the narrow-leaved deciduous forests, species of Burseraceae and Fabaceae families predominate.
### Table 1 List of species that include scientific name, local name, families and growth habit of all woody species encountered at Arero district, Borana

<table>
<thead>
<tr>
<th>SCIENTIFIC NAME</th>
<th>LOCAL NAME</th>
<th>FAMILY</th>
<th>HABIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia bussei Harms ex S. Jostedt</td>
<td>Hallo</td>
<td>Fabaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Acacia mellifera (Vahl.) Benth</td>
<td>Saphanse guracha</td>
<td>Fabaceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Acacia oerfota (Forssk.) Schweinf.</td>
<td>Waanga</td>
<td>Fabaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Acacia senegal (L.) Wildl.</td>
<td>Sephansa diimaa</td>
<td>Fabaceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Acacia tortilis (Forssk.) Hayne</td>
<td>Dhadacha</td>
<td>Fabaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Blepharispermum pubescens S.</td>
<td>Baanya</td>
<td>Asteraceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Boswellia microphylla Chiov.</td>
<td>Ilkibukisa</td>
<td>Burseraceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Boswellia neglecta S. Moore</td>
<td>Dakkara</td>
<td>Burseraceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Boswellia rivae ???</td>
<td>Dakkara</td>
<td>Burseraceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Commiphora africana (A. Rich.) ???</td>
<td>Hammesa dhiiroo</td>
<td>Burseraceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Commiphora balaensis (Ehrenb.) Egle.</td>
<td>Agarsuu</td>
<td>Burseraceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Commiphora boranensis ???</td>
<td>Rigga qeeroo</td>
<td>Burseraceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Commiphora habessinica (Berg.)</td>
<td>Hoomacho</td>
<td>Burseraceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Commiphora kua (R.Br.ex Royle) Vollesen</td>
<td>Callanqaa</td>
<td>Burseraceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Commiphora myrrha ???</td>
<td>Qumbii</td>
<td>Burseraceae</td>
<td>Tree</td>
</tr>
</tbody>
</table>
SCIENTIFIC NAME

Commiphora schimperi (Berg.) Egngl.
Commiphora terebinthina Vollesen
Delonix baccal (Chiov.) Bak
Delonix elata (L.) Gamble
Dodonea angustifolia L.f.
Erythrina melanacantha Taub. ex Harms
Grewia bicolour Juss.
Grewia tembensis Fresen.
Grewia villosa Willd.
Harmsia sidoides K.Schum.
Hibiscus crassinervius Hochst ex A.Rich.
Ipomoea donaldsonii Rendle
Kirkia burgeri Stannard subsp. burgerii
Lanea rivae (Chiov.) Sacleux
Lanea triphylla ???
Maerua triphylla A.Rich.
<table>
<thead>
<tr>
<th>LOCAL NAME</th>
<th>FAMILY</th>
<th>HABIT</th>
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<tr>
<td>Hammesa qayyoo</td>
<td>Burseraceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Sangga igguu</td>
<td>Burseraceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>Ballanjii</td>
<td>Fabaceae</td>
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<tr>
<td>Sukella</td>
<td>Fabaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Dhitacha</td>
<td>Sapindaceae</td>
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</tr>
<tr>
<td>Waleensuu</td>
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<td>Tree</td>
</tr>
<tr>
<td>Haroorressa</td>
<td>Tiliaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Dheekka</td>
<td>Tiliaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Ogomdi</td>
<td>Tiliaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Qaxxee</td>
<td>Sterculiaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Bungalla</td>
<td>Malvaceae</td>
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</tr>
<tr>
<td>Dhaliyyee</td>
<td>Convolvulaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Bisdhuga</td>
<td>Simaroubaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Handarakaa</td>
<td>Anacardiaceae</td>
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<tr>
<td></td>
<td>Anacardiaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Dhumayoo</td>
<td>Capparindaceae</td>
<td>Tree/shrub</td>
</tr>
<tr>
<td>SCIENTIFIC NAME</td>
<td>LOCAL NAME</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Ormocarpum trichocarpum (Taub)</td>
<td>Buutiyee</td>
<td></td>
</tr>
<tr>
<td>Plectranthus ignarius (Schweinf.)</td>
<td>Barbarressa</td>
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</tr>
<tr>
<td>Premna schimperi Engl.</td>
<td>Xaaxessaa</td>
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<tr>
<td>Sesamothamus rivae Engl.</td>
<td>Lallaaftoo</td>
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<tr>
<td>Sterculia stenocarpa H. Winkler</td>
<td>Qarari</td>
<td></td>
</tr>
<tr>
<td>Terminalia brownii Fresen.</td>
<td>Birresa</td>
<td></td>
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<tr>
<td>Terminalia prunioides Laws</td>
<td>Qoroboo</td>
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<tr>
<td>Vernonia cinerascens Sch. Bip.</td>
<td>Qaxee dhaltu</td>
<td></td>
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</table>

*Source: Adefris Worku, 2006*
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Fabaceae</td>
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</tr>
<tr>
<td>Laminaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Verbenaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Pedaliaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Sterculiaceae</td>
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<td>Combretaceae</td>
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<tr>
<td>Asteraceae</td>
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</table>
Table 2 List of tree species in the Central Rift Valley of Ethiopia

<table>
<thead>
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<th>NO.</th>
<th>SPECIES</th>
<th>FAMILY</th>
<th>HABIT</th>
</tr>
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<tr>
<td>1</td>
<td>Acacia Senegal</td>
<td>Fabaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>2</td>
<td>A. tortilis</td>
<td>Fabaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>3</td>
<td>A. seyal</td>
<td>Fabaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>4</td>
<td>A. etbaica</td>
<td>Fabaceae</td>
<td>Tree/Shrub</td>
</tr>
<tr>
<td>5</td>
<td>Balanites aegyptiaca</td>
<td>Balanitaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>6</td>
<td>Maytenus senegalensis</td>
<td>Celastraceae</td>
<td>Tree</td>
</tr>
<tr>
<td>7</td>
<td>Ziziphus mucronata</td>
<td>Rhamnaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>8</td>
<td>Dichrostachys cinerea</td>
<td>Fabaceae</td>
<td>Shrub</td>
</tr>
</tbody>
</table>

Source: Dagnew Yebeyen, 2006

What is interesting about the species composition of woodlands (narrow-leaved deciduous forests) of Ethiopia is their richness with gum and resin producing Acacia, Boswellia and Commiphora species (Mulugeta Lemenih, 2005). The genus Commiphora is the most diverse represented by nine species, and contributing to 14.1% of the species composition of Borana Acacia-Commiphora (narrow-leaved) forest followed by the genus Acacia represented by five species (Adefris Worku, 2006). Similarly, in the Central Rift Valley A. senegal, the source of commercial gum arabic, is one of the most frequent and abundant species (Dagnew Yebeyen, 2006).

Regeneration status

Regeneration is a central component of tropical dry forest ecosystem dynamics and sustainable forest utilization is only possible if adequate regeneration exists. Most of the species in the dry forests of Ethiopia regenerate from seeds and vegetative means (coppice and root/stump sprouts). The family Burseraceae is known for its ease of vegetative propagation. However, few studies investigated the regeneration profiles of species in the Acacia-Commiphora forests of Ethiopia. Regeneration profiles of species vary depending on geographical location, vegetation formation, species type and the degree of disturbances. Human caused disturbances such as (i) intensive removal of trees for construction and fuel, (ii) forest grazing, (iii) conversion, and (iv) forest fire have significant negative impacts on the regeneration of a species.
In this paper two cases are presented, one from the Central Rift Valley forests and the other from Borana narrow-leaved deciduous forests.

The study from CRV (Dagnew Yebeyen, 2006) showed that population structure of the entire vegetation and selected species composition of the narrow-leaved deciduous forest varies depending on the degree of disturbance (Figure 1a and b). The vegetation on the three sites (excluding the controlled grazing site) was found to exhibit more or less an inverted "J-shape" structure although the occurrence of stems per diameter class varied considerably from site to site (Figure 1a). In general, human related disturbances such as farming and grazing appear to encourage seedling emergence (regeneration) (Figure 1a) which is a typical feature of some dryland woody species (Dagnew Yebeyen, 2006).

Figure 1a Population structure (diameter class based) of narrow-leaved deciduous forests under various land cover/land use categories of the Central Rift Valley of Ethiopia (Diameter Classes: Class 1 = 0 – 4 cm; Class 2 = 4 – 8 cm; Class 3 = 8 – 12 cm; Class 4 = 12 – 16 cm; Class 5 = 16 – 20 cm; Class 6 = 20 – 24 cm; Class 7 = 24 – 28 cm; Class 8 = 28 – 32 cm; Class 9 = 32 – 36 cm; Class 10 = 36 – 40 cm; Class 11 = 40 – 44 cm; Class 12 = 44 – 48 cm; Class 13 = 48 – 52 cm; Class 14 = 52 – 56 cm).
Regeneration patterns of selected species also show variation depending on human disturbance. For instance, the population structure of A. senegal in the intact and farmland site shows large seedling population on the farmland than in the intact forest showing that disturbance encourages seedling emergency (Figure 1b). However, on the farmlands, population of mature trees and their diameter class is lower indicating removal of bigger trees by cutting from the farmlands (Dagnew Yebeyen, 2006).

Figure 1b Population structure of A. senegal at two contrasting sites: a) protected site and b) farmland in Central Rift Valley of Ethiopia (Diameter Classes: Class 1 = 0 – 4 cm; Class 2 = 4 – 8 cm; Class 3 = 8 – 12 cm; Class 4 = 12 – 16 cm; Class 5 = 16 – 20 cm; Class 6 = 20 – 24 cm; Class 7 = 24 – 28 cm; Class 8 = 28 – 32 cm; Class 9 = 32 – 36 cm; Class 10 = 36 – 40 cm; Class 11 = 40 – 44 cm; Class 12 = 44 – 48 cm; Class 13 = 48 – 52 cm; Class 14 = 52 – 56 cm (Source: Dagnew Yebeyen, 2006)
The study from Borana also showed that narrow-leaved deciduous forest vegetation as a whole, exhibit an inverted “J-shape” structure (Figure 2a). However, analysis of selected species indicated variable population structure and regeneration profile (Figure 2b, c and d). While species such as Acacia senegal, A. seyal, A. mellifera, Commiphora africana and Boswellia neglecta show better populations of sapling and seedling, others such as C. kua, C. habessinica, C. schimperi, and A. seyal from Yabello and B. neglecta, B. microphylla, C. boranensis, C. terebinthina, C. baluensis and C. confusa show population that deviate from inverted “J-shape” indicating some problems with their regeneration status (Adefris Worku, 2006).

Figure 2 Population structure (diameter class based) of (a) the entire vegetation and (b-d) selected three species in Borana narrow-leaved deciduous forests (Diameter class in cm: 1=0 < 4 cm, 2=4 < 8, 3=8 < 12, 4=12<16, 5=16<20, 6=20<24, 6=24<28, 7=28<32, 8=32<34, 9=34<38 (Source: Adefris Worku, 2006)
Socio-economic importance of Acacia-Commiphora forests

Until recently, lowland woodlands in general and Acacia-Commiphora forests in particular have been hosting nomadic and pastoral community. The nomads have been using the vegetation for extensive livestock production system. Due to the dominance of pastoralism in the woodlands, this vegetation has been recognized as rangelands with a resulting conflict of interest between the forest sector and agriculture. Over time, its significance as source of wood and non-wood forest products began to gain importance. Today, the narrow-leaved deciduous forests, while still providing livestock husbandry also provide diverse and commercially important non-wood products such as gum arabic, frankincense and myrrh. The following sections capture some of the important socio-economic roles that deciduous forests in general and Acacia-Commiphora narrow-leaved deciduous forests in particular are playing in the country.

Contribution to livestock production

Woodlands are relatively sparsely populated hosting only 12-15% of Ethiopia’s human population of over 80 million. The inhabitants of deciduous forests are mostly nomadic and agro-pastoralists. These people have depended and still depend on deciduous forest resources including the perennial trees/shrubs for livestock feed. Livestock production, which is the mainstay of the agro-pastoral and pastoral economy, is heavily dependent on fodder supplied from the woody plant biomass (Kuchar, 1995). Particularly in the dry season as well as during droughts, trees and shrubs are the only source of fodder for their livestock. The families of Burseraceae and Fabaceae (subfamily Mimosoideae) are known for their provision of nutritious fodder, and virtually all plants in the two families are palatable to livestock (Kuchar, 1988; Farah, 1994). Compared with annual grasses, perennial woody vegetation supply more fodder during prolonged drought periods, which makes them more useful in dryland regions. The priority demand on the vegetation resources of the pastoral and agro-pastoral community is for use as rangelands (Mulugeta Lemenih et al., 2003).

Income diversification

Narrow-leaved deciduous forests provide numerous products that generate cash income. The principal sources of cash income are fuel wood (firewood and charcoal), gum and resin. Commercially important major gum and gum resin produced from the Acacia-Commiphora forests of Ethiopia are gum arabic, frankincense/olibanum, myrrh and opoponax.
Gum arabic in Ethiopia is obtained from two Acacia species, namely, Acacia senegal and A. seyal both of which are common species in the Acacia-Commiphora narrow-leaved deciduous forests. Frankincense/olibanum is a gum resin tapped from several species of the genus Boswellia, and typically the Ogaden and Borana type frankincense are obtained from Acacia-Commiphora forests. Myrrh, opoponax and myrrh-like gum resin are mainly concentrated in the Acacia-Commiphora forests and are products of Commiphora species (Plate 2).

Gum and resin products are important means of income for households residing in producing areas. In some situation, gum and resin provide the only source of household income, while in others it stands as a safety net (Mulugeta Lemenih et al., 2003; Adefris Worku, 2006). For instance, a study made in Liban, southeastern lowlands showed that the annual income from collection and sale of oleo-gum resin is the second most important means of household livelihood (Mulugeta Lemenih et al., 2003). The economic incentive provided by gum and resin has wider implications in the overall socio-economic conditions of households living in arid and semi-arid lowlands.

The diversification of their economy implies potential minimization of the risks associated with frequent crop and fodder failure as a result of the commonly recurring droughts. Particularly, in the drylands where the economy of pastoralists and agro-pastoralists is not able to produce all the food their families need for basic subsistence, collection of gum and resin may play a great role in supplementing income for the household livelihood. The importance of forest income usually lies more in its timing than in its magnitude. One advantage associated with the collection of gum and resin in this regard is their availability only during dry seasons when forage and grains are scarce (Mulugeta Lemenih et al., 2003) and thus, used as alternative source of income during dry seasons.

Gum and resin are also exported and hence are a source of foreign currency for the country. Between 1998 and 2007 about 25,192 tons, approximately 2,519 tons per year of natural gum and resin were exported from Ethiopia. This is worth ETB 307,248,000 (USD 34,138,670) (Mulugeta Lemenih and Habtemariam Kassa, 2008). Domestic sales during the same period are estimated at 750 tons per annum. There are over 40 import destinations (countries) for gum and resin products from Ethiopia. The bulk of the products are destined to China (29%), Germany (13%), Persian Gulf (9.5%), Tunisia (8.6%) and United Arab Emirates (7.3%) among others (Mulugeta Lemenih and Habtemariam Kassa, 2008). If extracted and managed
these products would provide investment opportunity and foreign currency earnings. Important lessons can be learnt from the Sudan on how to develop and benefit from the sub-sector.

Plate 2 Myrrh, opoponax, incense and gum arabic products collected from Acacia-Commiphora narrow-leaved deciduous forests of Borana and on local market for sale

Income diversification

The dry forests in general and the Acacia-Commiphora narrow-leaved deciduous forests in particular have been facing multiple natural and anthropogenic problems that threaten their sustainable development and utilization. In the following analysis the most pertinent factors threatening the Acacia-Commiphora forests is presented.
Bush encroachment and invasion of alien species

In recent decades bush encroachment and invasion are emerging as one of the severe challenges facing the Acacia-Commiphora forests. Both bush encroachment and invasion by alien species are causing reduction in native biodiversity as well as altering several ecosystem processes mostly in eastern and southern Ethiopia. The most affected areas are woodlands and thickets in Afar and Borana plateau. The most notorious alien invasive species in the Acacia-Commiphora forests and woodlands of Ethiopia is Prosopis juliflora.

Similarly, a number of native species are emerging as encroachers in other cases. For instance, a study in Borana rangeland showed that bushlands are showing tremendous increase in cover from time to time. The cover of bushlands increased from 51% in 1986 to 53.8% in 2002 and continued increasing to about 57% of the total land of the rangeland in 2010 (Table 3). The increase in bush cover was obtained from the conversion of originally non-bushlands such as grasslands and bare lands rather than the spatial expansion or radiation of the originally existing bushlands. Surprisingly, the original bushland cover of 1986 shrank by 13.6% in 2002 and again by 13.2% in 2010 (Table 3) while a shift from other land cover to bushlands was 16.3% between 1986 and 2002, and a further 18.7% in 2010 (Table 3). This is what resulted in the net increment of bush cover over the area.

The net increase in bush cover confirms the problem of bush encroachment in the Borana rangeland. This also confers with several other studies in the area. In the early 1980s, the Borana rangelands was affected by 40% due to bush encroachment (Coppock, 1993) which was reported to have increased to 52% early in 1990s (Gemedo Dalle et al., 2006). Ayana Angassa (2007) also estimated the further increase in bush cover in the 2000s, which this study confirms objectively. Today, in Borana rangeland only about 43% of the area is free from bush encroachment and is thus viable for extensive range purpose (Figure 2). However, even these bush-free areas are subject to competition for various uses such as croplands (Kamara et al., 2004; Bassi and Boku Tache, 2007; Homann et al., 2008).
Table 3 Extent of land cover changes in 24 years (1986-2010) in Borana Acacia-Commiphora forest area

<table>
<thead>
<tr>
<th>Land cover type</th>
<th>Unchanged area</th>
<th>Reduction in No change</th>
<th>Cover Increment area</th>
<th>Total area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ha</td>
<td>Ha %</td>
<td>Ha %</td>
<td>ha %</td>
</tr>
<tr>
<td>Forest</td>
<td>18954</td>
<td>0.9</td>
<td>15699 0.7</td>
<td>2060452 97.7</td>
</tr>
<tr>
<td>Bushland</td>
<td>800280</td>
<td>40</td>
<td>278508 13.2</td>
<td>634680 30.1</td>
</tr>
<tr>
<td>Bare land</td>
<td>199336</td>
<td>9.5</td>
<td>359992 17.1</td>
<td>1232743 58.5</td>
</tr>
<tr>
<td>Grassland</td>
<td>135746</td>
<td>6.4</td>
<td>307316 14.6</td>
<td>1428496 67.8</td>
</tr>
</tbody>
</table>

Source: Daniel Jalata, 2010

Demographic pressure

The human and livestock population in the drylands of Ethiopia are increasing rapidly. Estimates show that natural population growth in the low drylands is about 2.7% (Sandford and Yohannes Habtu, 2002). Higher population implies increasing demand for forest products, grazing and farming areas, which are becoming the most serious forces of degradation (Mulugeta Lemenih and Habtemariam Kassa, 2010). Self-initiated and government sponsored re-settlement programmes are also conducted in dryland narrow-leaved deciduous forests. Successive governments used resettlement in the lowland dry deciduous forests as a strategy for reducing food insecurity of vulnerable households in the degraded highland areas. Between 2000 and 2004 alone, about 440,000 household heads or 2.2 million people have been formally resettled in four regional states of Ethiopia namely, Amhara, Oromia, SNNPR and Tigray. Considering the wood demand for construction and fuel wood as well as land for crop cultivation, moving such number of people would lead to clearance of an estimated 1.7 million ha during the same period (Mulugeta Lemenih and Habtemariam Kassa, 2010). Clearance for subsistence agriculture is the leading cause of deforestation in the dry forests of Ethiopia (Mulugeta Lemenih et al., 2008), causing the loss of 91,400 ha of woodlands (deciduous forests) and 76,400 ha of shrublands annually (WBISPP, 2004).

Clearance is exacerbated by the open access nature of land as a result of weak regulatory framework whether formal or informal at local level (see subsequent section). Settlements and areas under crops hamper seasonal mobility of the indigenous people and this may instigate conflicts.
Reducing mobility may force pastoralists to convert to agro-pastoralism or even sedentary farming as a way of life, a common transformation observed in many Acacia-Commiphora forests such as CRV and the Borana. The changing life style coupled with the population increase encourages expansion of villages with large number of livestock concentrated in limited areas, resulting in overgrazing. This, in turn, increases the demand for products for construction and energy and triggers additional and intense deforestation in certain areas.

Climatic variability, climate change and chronic food insecurity

Drylands of Ethiopia are vulnerable to climatic change and variability. The climate variability map of Africa constructed by Thornton et al. (2006) put Ethiopia as one of the countries vulnerable to climate change with the least capacity to respond while Vincent (2004) represents Ethiopia as the 7th most vulnerable country in Africa. Moreover, evidence of climate change on the ground are very apparent. In the last 50 years the annual average minimum and maximum temperatures of the country have been increasing every decade by about 0.25 and 0.1°C, respectively (INCE, 2001), a change that is also perceived by the local people (Temesgen Deressa et al., 2008). Coupled with ecosystem degradation, climate change will continue to pose a significant challenge to Ethiopia given its limited adaptive capacity.

According to some official documents (INCE, 2001; NAPA, 2007), in addition to biodiversity (flora and fauna) sectors such as agriculture, human health, water and energy are climate-sensitive sectors of the country. Sector wise, agriculture is identified as the most vulnerable. In terms of livelihood, subsistence farmers and pastoralists, who together comprise 84% of the country’s population, are the most vulnerable to the effects of climate change. Drought is the single most important climate-related natural hazard followed by floods even though climate-related hazards in Ethiopia include heavy rains, strong winds, frost and heat waves (high temperatures). Major floods which caused loss of life and property occurred in different parts of the country in 1988, 1993-6 and 2006. The effects of drought and floods are severe in the dryland areas.

According to FAO (2005), the combined effects of below average rainfall, conflict, insecurity and higher than average food prices in the Horn of Africa have resulted in more than 17 million food insecure people. The same trend was also confirmed by the report of USAID (USAID, 2009). In Ethiopia, erratic rainfall and poor crop production coupled with rising cereal prices, subjected nearly 5 million people to be dependent on emergency food aid, over and above the 7.2 million Productive Safety Net Programme beneficiaries (Cullis, 2009).
As a coping mechanism, most households revert to public resources such as forests and harvest wood and non-wood products for subsistence as well as to augment family income. Food insecurity and persistent deforestation in the dry ecosystems could lead to desertification which threatens vast drylands of Ethiopia (Tamire Hawando, 1997).

Land degradation can be defined as the reduction or loss of economic productivity of land due to loss of physical, chemical or biological properties of land. This loss may arise from inappropriate use of land resources such as soil, water and vegetation. Land degradation is a great threat to environmental sustainability and poverty reduction. Thus, it requires commitment and enormous mobilization of resources to prevent and improve this situation. There are complex causes although the direct ones are deforestation, improper cultivation (poor soil and water conservation practices), soil erosion, loss of soil fertility particularly organic matter and improper livestock husbandry. Inappropriate land use systems, lack of legally enforceable tenure security and/or accountability in land use and management exacerbate land degradation. Land degradation in the drylands is increasing due to poor governance of access to and use of resources, notably forests and land.

Given the ecological sensitivity, cultivation of crops without adequate soil and water management practices will quickly deteriorate the biological and physico-chemical properties of the soil. Removal of perennial plant cover in drylands causes rapid reduction of soil organic matter (SOM), which further induces soil erosion by water and wind, soil crusting by raindrop splash and salinization by evaporation. Particularly, vegetation clearance followed by repeated tillage that also involve crop residue burning and harvesting causes substantial reduction in SOM contents (Mulugeta Lemenih and Fisseha Itanna, 2005; Mulugeta Lemenih et al., 2005). For instance, a study along a topo/climo sequence around the Central Ethiopian Rift Valley area showed that deforestation followed by subsequent cultivation causes soil carbon (C) losses of 94 and 1,748 kg/ha/year from semi-arid and dry sub-humid zones, respectively (Mulugeta Lemenih and Fisseha Itanna, 2005). Another study in the same area showed that cleared forestlands cannot be used sustainably for more than 25 years (Mulugeta Lemenih et al., 2005). According to this study, subsequent cultivation for over 25 years would cause severe soil degradation. Furthermore, deforestation and subsequent cultivation of any intensity have been shown to degrade and alter the soil seed flora of the forest, a phenomenon that will reduce the potential for future secondary forest regeneration (Demel Teketay, 1997; Mulugeta Lemenih and Demel Teketay, 2004).
Reduction in SOM in turn reduces soil aggregate stability. Unstable and poorly developed structures result in soil compaction which increases surface runoff, lowers porosity and permeability to water, and lowers water holding capacity. Lower permeability, in turn, results in increased edaphic aridity and hence reduced productivity. Low SOM also means lower biological activity from micro-, meso- and macroflora and fauna, particularly symbionts. The decline in S, Ca, Na, Mg, Fe, Cu, Zn, Co, etc results in reduced fertility. The ultimate consequences of all these processes are low carrying capacity of the land, reduction in regeneration capability of the ecosystem, loss of biodiversity, depletion of water availability and finally, abandonment of the area as a desert land. These and other signs of desertification are becoming common across the drylands of Ethiopia.

Policy related challenges

Given the dominant role of agriculture in the economy, the emphasis of the government has been on agriculture in general and on small holder farming in particular as the land-related legal and policy documents reflect. Farmers in some regions are required to stay on-farm to ensure holding and use rights. Some point out that such provisions would curtail peoples’ mobility and tie the population to rural areas. In areas with less forested lands this would further result in interfamly land redistribution or landlessness. This, coupled with high population growth, compounds the problem by continuous encroachment of farmlands into forested landscapes as well as overgrazing. Landlessness and shrinking farm sizes promote migration from the highlands to the drylands. This movement of people to drylands is also supported by the government through its resettlement programme that aims at settling hundreds of thousands of households from degraded highlands to the drylands in the lowlands (PASDEP, 2006).

On the other hand, several policy documents state the severity of environmental degradation, particularly in the dryland areas of the country. Ethiopia has signed the convention on combating desertification, and also developed a National Action Plan for combating desertification. The country has also issued Environmental Policy (EPA, 1998) and enacted Rural Land Administration and Land Use Proclamation, and the Forest Conservation, Development and Utilization Policy. In the Environment Policy, population growth and climate variability were recognized as threats. The rural land administration and land use policy contains important provisions to facilitate sustainable land use.
However, there are no specific land use plans developed to guide field implementation and restrict improper use. Land management obligations, measures and rights are not worked out to implement and enforce. Most of the policies and proclamations relevant to the dryland resources lack accountable and stable institutions to see their implementation on the ground. Most do not have detailed implementation guidelines either. Thus, their implementation and subsequent revision aspects leave much to be desired. Inter-sectoral policy integrations are also very weak, in some cases, with contradicting or conflicting contents (e.g. conservation and investment).

The aforementioned policy constraints led deciduous forests to the de facto open access for all forms of misuse. Conversion of deciduous forests to crop fields, over grazing and excessive wood harvest for fuel wood production became a common occurrence all over the deciduous forests.

Agro-fuel related development

Ethiopia imports its entire petroleum fuel requirement and the demand for petroleum fuel is rising rapidly due to a growing economy and expanding infrastructure. This imported petroleum is the major source of greenhouse gas (GHG) emissions in the country. Of the total CO2 emission of 2,596 Gt in 1994, 88% is contributed from fossil fuel combustion in the Energy and Transport (road) sectors. The annual consumption of petroleum fuels amounts to 1.1 million tons. Imported petroleum products account for 40% of the total import items and absorb 60% of the export earnings. It is thus the largest burden to the country deterring its rapid socio-economic advancement. Renewable energies, including agro-fuel, are assumed to have substantial contribution to development in poor countries like Ethiopia that heavily depend on imported commercial fuel. The following are some of the advantages foreseen from Ethiopia’s context:

- Import substitution to petroleum;
- Provide export earning, thus expansion of the GDP;
- Enhance agricultural development and agro-processing; thus playing a role in job creation and improving income of the people, which also contributes to strengthening the adaptive capacity of citizens to likely impacts of climate change by improving economic food security;
• Improve agricultural land productivity through integration of agro-fuel development programme with land use plan; and
• Being clean energy and carbon neutral, decrease environmental pollution and emissions of GHG from the country.

Agro-fuel is the only alternative fuel approved by the Environmental Protection Authority for its environmental friendliness in Ethiopia. The current agro-fuel development in the country emphasizes on the production of: (i) Agro-ethanol from sugar beet, sugar cane, sweet sorghum and others, and (ii) agro-diesel from jatropha, castor bean plants and palm.

The total available potential land for the production of feedstock for agro-diesel is estimated at about 23,305,890 ha (Rezene Fessehaie, 2009). Currently, about 52 developers have been registered for the cultivation of energy crops such as jatropha and castor beans in Ethiopia, out of which 14 have already begun operation on about 350,000 ha of land (Table 4). However, the land requirements of all the registered developers add up to 1.65 million ha.
<table>
<thead>
<tr>
<th>Company Name</th>
<th>Region</th>
<th>Out-growers I (ha)</th>
<th>Out-growers land (ha)</th>
<th>Agro-crop plant type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun Biofuels Eth/NBC</td>
<td>Benshangul</td>
<td></td>
<td></td>
<td>Jatropha</td>
</tr>
<tr>
<td>Amabasal Jatropha Project</td>
<td>Benshangul</td>
<td></td>
<td></td>
<td>Jatropha</td>
</tr>
<tr>
<td>Jatropha Biofuels Agro Industry</td>
<td>Benshangul</td>
<td></td>
<td></td>
<td>Jatropha</td>
</tr>
<tr>
<td>IDC Investment</td>
<td>Benshangul</td>
<td></td>
<td></td>
<td>Jatropha</td>
</tr>
<tr>
<td>ORDA</td>
<td>Amhara</td>
<td></td>
<td></td>
<td>Jatropha</td>
</tr>
<tr>
<td>Jemal Ibrahim</td>
<td>Amhara</td>
<td></td>
<td></td>
<td>Castor bean</td>
</tr>
<tr>
<td>BDFC Ethiopia Industry</td>
<td>Amhara</td>
<td>30,000</td>
<td>30,000</td>
<td>Sugarcane/sugar beet</td>
</tr>
<tr>
<td>A Belgium Company</td>
<td>Amhara</td>
<td></td>
<td></td>
<td>Castor bean</td>
</tr>
<tr>
<td>Flora Eco Power Ethiopia</td>
<td>Oromia</td>
<td>5000</td>
<td>5000</td>
<td>Castor bean</td>
</tr>
<tr>
<td>Petro Palm Corporation Ethiopia</td>
<td>Oromia</td>
<td></td>
<td></td>
<td>Castor bean/Jatropha</td>
</tr>
<tr>
<td>VATIC International Business</td>
<td>Oromia</td>
<td></td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Global Energy Ethiopia</td>
<td>SNNPR</td>
<td>7500</td>
<td>7500</td>
<td>Castor bean</td>
</tr>
<tr>
<td>Omo Sheleko Agro Industry</td>
<td>SNNPR</td>
<td></td>
<td></td>
<td>Palm</td>
</tr>
<tr>
<td>Sun Biofuels Eth/NBC</td>
<td>SNNPR</td>
<td></td>
<td></td>
<td>Jatropha</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>42,500</strong></td>
<td><strong>42,500</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Source: Hilawe Lakew and Yohannes Shife*
A range of traditional institutions have been used in determining access to, use and management of dryland resources, particularly rangelands, forests and water resources. Borana is a good example in this respect. The Borana people own a strong indigenous institution called Gada, with well recognized role of managing the rangelands and water resources in the entire Borana dryland. The complexities of Gada are described by many scholars (Asmerom Legesse, 1973; 2000; Coppock, 1994; Watson, 2003; Homann et al., 2008). This egalitarian Borana institution is very popular and is often cited as a model of sustainable pastoralism in sub-Saharan Africa (e.g., Coppock, 1994; Watson, 2003; Homann et al., 2008).

The Gada system is primarily concerned with regulating the use of the Borana natural resources, maintaining peace among the multitudes of users, and protecting them and their cattle from external invasion (Coppock, 1994; Watson, 2003). The system comprises decentralized social organization to govern resource use. The structure begins from head of a household at micro-unit in the social organization through Kora Olla (village council), Kora ardaa (area/county council) and Kora Gossa (clan council) to Gumi gayyo (an assembly of all Borana people and/or their representatives). A consensus on important community issues - such as redefinition and enforcement of rules, regulations, and norms is reached through open, participatory discussions in assemblies beginning from the village council and terminating at the macro (Gumi gayyo) level. Gumi gayyo is held every eight years to discuss issues such as resource conflicts and cardinal rules, including those that have been violated, and to collectively devise the future of the Borana society. Gada used to play lead role in managing dryland resources, at least for few hundred years. However, its role has been weakened in the recent past.

The Borana communal-grazing system allows access to pasture and water to each member of the Borana society, contingent upon compliance with the prevailing rules and regulations, and the performance of duties and responsibilities. The entire Borana Plateau is divided into traditional administrative units called maddas, which geographically are configured around a permanent water source (traditional deep well or permanent ponds). Each water source is administered by a father of the well. The father of a well regulates its use, organizes its maintenance, and coordinates with madda elders for the implementation of rules, regulations, and sanctions regarding the water source. Each madda is subdivided into ardas: a collection of villages or encampments (ollas). Each arda has jurisdiction over some form of grazing area, cultivation land, and, to a lesser extent, water resources.
The ollas comprise about 10 households and are the smallest units of communal resource management. Three types of grazing arrangements are recognized and these are: warra, forra and calf enclosures. Forra grazing areas are designated for grazing bulls and non-lactating cows (dry herds), and are customarily open to all Borana people. Transit areas around permanent water points are also forra. Permanent settlement in forra areas is prohibited by madda elders. Such areas are regarded as fall back areas for all Borana people during periods of forage scarcity. Warra areas are grazing areas for lactating cows, and for sick and weak animals that return to the encampment every day so that they can be milked and looked after. Areas designated as warra are only open to members of the same arda but can be used by members of different ardas under special arrangements, usually on a reciprocal basis. The most individualized pastures in Borana are calf enclosures.

Calf enclosures are fenced pastures that are reserved for use by calves and to a lesser extent, by milking cows mainly in the dry season. The use of calf enclosures is restricted to members of the community that erected the fences, usually one or more ollas. Access to an enclosure is restricted only to periods of absolute forage scarcity and for specific types of animals. The Gada institution does not constitute specific rules geared towards gum bearing species and gum-resin collection. These species are part and parcel of the forests and are managed as components of the entire vegetation. The absence of specific rules could relate to the fact that the importance of gum and resin to livelihood is still low and its production on a relatively recognizable scale is just a recent phenomenon.

Unfortunately, changing biophysical, socio-economic and political conditions are threatening the role and the strength of the Gada institution in governing the resource base. The major challenge is a growing lack of adherence of the community to the Gada norms. The lack of adherence originates from the multi-dimensional changes in life style of the Borana people as a result of (i) expanding urbanization and its ‘modern culture’ with more individualistic and changing life styles; (ii) changing livelihood strategy from pure pastoralism towards agro-pastoralism and petty trade; (iii) growing influence over the Gada rulers either through corruption or political interferences and subsequent lack of trust by communities; (iv) resource scarcity particularly, pasture and water due to recurring drought and/or bush encroachment; (v) population pressure, regionalism (ethnicism) that curtailed pastoral mobility; and (v) exogenous interventions (state and NGOs) that assist new way of sedentary mode of life. The sedentary mode is also associated with increasing privatization of communal rangelands and conversion to private crop fields.
Summary and the way forward

Deciduous forests in general and that of Acacia-Commiphora forests in particular are important natural endowments of drylands that have been and are still contributing to human welfare and environmental health. These forests not only provide a direct and indirect means of support to the livelihood of 15-20% of the population of the country but are also a source of commercially significant gum-resin resources which have immense socio-economic value beyond the local level. Despite the growing local and national importance of the Acacia-Commiphora narrow-leaved deciduous forests, their management is facing multiple challenges.

Designing and promoting sustainable production system would not only conserve the resources but enhance their sustainable socio-economic and ecological significance. To achieve such dual goals, it is essential to incur concerted and integrated multi-dimensional management interventions. The multi-dimension management interventions require multi-institutional collaboration and integration of their actions to optimize the impact for the sustained production and development of the resources. The activities may be shared among various institutions and stakeholders from federal through regional to local levels including the private sector. The following recommendations can be made:

- Mainstreaming natural resources management in resettlement programs;
- Practising appropriate land use planning whereby areas best suited for development and intensification of agriculture and areas needed for conservation are identified and implemented;
- Strengthening land tenure security and control free/open access;
- Improving integration, cross referencing of inter-sector policies;
- Enhancing institutional frameworks and capacity building in implementation and rule/law enforcement;
- Promoting on-farm and homestead tree planting/management and agroforestry practices in arid, semi-arid and dry sub-humid parts of Ethiopia;
- Improving the governance of area exclosures;
• Strengthening the capacity of civil societies working in dryland areas and specifically targeting forests to engage more effectively with policy debates on dryland development, including through training and exchange of experiences;
• Re-invigorating traditional institutions and providing them legal recognition;
• Optimizing the market-based, high value farming, livestock and forestry production systems when ever and where ever possible; and
• Introducing commercial – sustainable – destocking system during droughts to reduce pressure on the forests.

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Introduction

Bamboo is a tropical or warm temperate member of grass family Poaceae (Gramineae) belonging to the sub-family Bambusoideae. It is a multipurpose plant with significant economic and environmental value. It grows in temperate, subtropical and tropical areas of all continents except Europe (Liese, 1985). There are more than 1,575 species of bamboo belonging to 111 genera reported from all over the world (Ohrnberger, 1999). These resources are distributed from 46° North to 47° South latitude with altitudes ranging from sea level to over 4,000 m in equatorial highlands (Soderstrom et al., 1988). About 80% of bamboo forestland and species in the world are distributed in Asia and Pacific regions (Soderstrom et al., 1988). Latin America also has a high biodiversity of bamboos with approximately 400-500 species.

The lowest diversity of bamboos is found in mainland Africa where five species naturally occur (Brystriakova et al., 2003). Africa possesses about 43 species of bamboo under 11 genera, covering an area of over 1.5 million ha (Kigomo, 1988). As described by Kigomo (1988), the most widely distributed African bamboo is categorized under three genera: Arundinaria, Oreobambos and Oxytenanthera.

The greatest potential for bamboo richness is in East Africa, particularly Ethiopia. The above mentioned three genera are distributed between 22° South and 16° North of the continent. The distribution patches of bamboo in general stretches from the temperate highland frost zone of Ethiopia upper reaches of the Nile River in the north, to the Basutoland highlands, Natal and Madagascar in the south. The highest diversity of bamboos in Africa, about 40 species, is found in Madagascar, which is strikingly richer in species than the mainland. Thirty two of these species are endemic and a single species, which is pan tropical in distribution, has been introduced from Asia (Brystriakova et al., 2003).

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This review paper aims to highlight the current status of bamboo forests of Ethiopia, its potential contribution to the national economy and the challenges of utilization of bamboo resources.

**Bamboo resources in Ethiopia**

Ethiopia has two indigenous bamboo species: the highland bamboo (Arundinaria alpina K. Schum. synonym: Yushania alpina) and the monotypic genus lowland bamboo Oxytenanthera abyssinica (A. Rich.) Munro. These species of bamboo are indigenous to Ethiopia and endemic to Africa (Kigomo, 1988). The Ethiopian natural bamboo forest is estimated to have been about one million ha before 14 years.

It is very important to point out that Ethiopia is the only country in Africa which has over 850,000 ha of Oxytenanthera abyssinica natural bamboo forest. Oxytenanthera abyssinica is a clumping (sympodial) type bamboo with “solid” culm at maturing age. It has an average culm diameter of 5 cm and height of 7 m. This species grows at an elevation between 1,000 to 1,800 m above sea level and is widely distributed in the western lowland areas of the country (Table 1).

**Table 1 Major lowland bamboo growing areas of Ethiopia**

<table>
<thead>
<tr>
<th>No.</th>
<th>Region</th>
<th>Sites/growing locations</th>
<th>Stand type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Benshangul Gumuz</td>
<td>Anbesa Chaka/Bambasi</td>
<td>Natural</td>
</tr>
<tr>
<td>2</td>
<td>Benshangul Gumuz</td>
<td>Kamish</td>
<td>Natural</td>
</tr>
<tr>
<td>3</td>
<td>Benshangul Gumuz</td>
<td>Komosha/Harkole</td>
<td>Natural</td>
</tr>
<tr>
<td>4</td>
<td>Benshangul Gumuz</td>
<td>Abramo</td>
<td>Natural</td>
</tr>
<tr>
<td>5</td>
<td>Benshangul Gumuz</td>
<td>Basha-buda</td>
<td>Natural</td>
</tr>
<tr>
<td>6</td>
<td>Benshangul Gumuz</td>
<td>Kurmuk</td>
<td>Natural</td>
</tr>
<tr>
<td>7</td>
<td>Benshangul Gumuz</td>
<td>Assosa</td>
<td>Natural</td>
</tr>
<tr>
<td>8</td>
<td>Benshangul Gumuz</td>
<td>Mandura</td>
<td>Natural</td>
</tr>
<tr>
<td>9</td>
<td>Benshangul Gumuz</td>
<td>Pawe</td>
<td>Natural</td>
</tr>
<tr>
<td>10</td>
<td>Benshangul Gumuz</td>
<td>Manbuk</td>
<td>Natural</td>
</tr>
<tr>
<td>11</td>
<td>Benshangul Gumuz</td>
<td>Galesa</td>
<td>Natural</td>
</tr>
<tr>
<td>12</td>
<td>Benshangul Gumuz</td>
<td>Bulen</td>
<td>Natural</td>
</tr>
<tr>
<td>13</td>
<td>Benshangul Gumuz</td>
<td>Dibate</td>
<td>Natural</td>
</tr>
</tbody>
</table>
Table 1 contd.

<table>
<thead>
<tr>
<th>No.</th>
<th>Region</th>
<th>Sites/growing locations</th>
<th>Stand type</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Oromia</td>
<td>Dedesa/Arjo</td>
<td>Natural</td>
</tr>
<tr>
<td>15</td>
<td>Oromia</td>
<td>Dedesa/Gimbi</td>
<td>Natural</td>
</tr>
<tr>
<td>16</td>
<td>Oromia</td>
<td>Begi</td>
<td>Natural</td>
</tr>
<tr>
<td>17</td>
<td>Oromia</td>
<td>Nejo</td>
<td>Natural</td>
</tr>
<tr>
<td>18</td>
<td>Oromia</td>
<td>Anger-Gutin</td>
<td>Natural</td>
</tr>
<tr>
<td>19</td>
<td>Amhara</td>
<td>Metema</td>
<td>Natural</td>
</tr>
</tbody>
</table>

Source: Ensermu Kelbessa et al., 2000

The species grows naturally in warm climates with average temperature of 35°C and mean annual rainfall between 900 to 1,400 mm (Anonymous, 1997). The average stocking of this bamboo forest is about 8,000 culms per ha with average biomass of 70.3 t/ha and the average annual increment of culm oven-dry matter is 10.1 t/ha. About 85% of the total bamboo forest of the country is covered with this species.

Arundinaria alpina is a non-clump forming bamboo with hollow culms. It has an average diameter of 8 cm and height of 17 m. About 15% or more than 130,000 ha of the bamboo forest in the country is covered with this species (Table 2).

Table 2 Major highland bamboo growing areas of Ethiopia

<table>
<thead>
<tr>
<th>No.</th>
<th>Region</th>
<th>Sites/growing locations</th>
<th>Stand type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oromia</td>
<td>Jibat mountain</td>
<td>Natural</td>
</tr>
<tr>
<td>2</td>
<td>Oromia</td>
<td>Tikur-inchini and Shenen</td>
<td>Homestead</td>
</tr>
<tr>
<td>3</td>
<td>Oromia</td>
<td>Bore</td>
<td>Homestead</td>
</tr>
<tr>
<td>4</td>
<td>Oromia</td>
<td>Bale mountains</td>
<td>Natural</td>
</tr>
<tr>
<td>5</td>
<td>Oromia</td>
<td>Harenna forest</td>
<td>Natural</td>
</tr>
<tr>
<td>6</td>
<td>Oromia</td>
<td>Agaro</td>
<td>Homestead</td>
</tr>
<tr>
<td>7</td>
<td>Oromia</td>
<td>Gera</td>
<td>Natural</td>
</tr>
<tr>
<td>8</td>
<td>Oromia</td>
<td>Degaga-Shashamane</td>
<td>Natural</td>
</tr>
<tr>
<td>9</td>
<td>SNNPR</td>
<td>Hagere-Selam</td>
<td>Homestead</td>
</tr>
</tbody>
</table>
Table 2 contd.

<table>
<thead>
<tr>
<th>No.</th>
<th>Region</th>
<th>Sites/growing locations</th>
<th>Stand type</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>SNNPR</td>
<td>Bensa</td>
<td>Natural, homestead</td>
</tr>
<tr>
<td>11</td>
<td>SNNPR</td>
<td>Bulea</td>
<td>Natural</td>
</tr>
<tr>
<td>12</td>
<td>SNNPR</td>
<td>Bonga</td>
<td>Natural</td>
</tr>
<tr>
<td>13</td>
<td>SNNPR</td>
<td>Chencha</td>
<td>Natural, homestead</td>
</tr>
<tr>
<td>14</td>
<td>SNNPR</td>
<td>Masha</td>
<td>Natural</td>
</tr>
<tr>
<td>15</td>
<td>SNNPR</td>
<td>Gesha</td>
<td>Natural</td>
</tr>
<tr>
<td>16</td>
<td>SNNPR</td>
<td>Gada</td>
<td>Natural</td>
</tr>
<tr>
<td>17</td>
<td>SNNPR</td>
<td>Baha-chapa</td>
<td>Natural</td>
</tr>
<tr>
<td>18</td>
<td>SNNPR</td>
<td>Indibir</td>
<td>Homestead</td>
</tr>
<tr>
<td>19</td>
<td>SNNPR</td>
<td>Jembero</td>
<td>Homestead</td>
</tr>
<tr>
<td>20</td>
<td>SNNPR</td>
<td>Ameya</td>
<td>Natural</td>
</tr>
<tr>
<td>21</td>
<td>Amhara</td>
<td>Injibara</td>
<td>Homestead</td>
</tr>
<tr>
<td>22</td>
<td>Amhara</td>
<td>Rob Gebeya</td>
<td>Homestead</td>
</tr>
<tr>
<td>23</td>
<td>Amhara</td>
<td>Debressia</td>
<td>Natural</td>
</tr>
<tr>
<td>24</td>
<td>Amhara</td>
<td>Debre Tabor</td>
<td>Natural, homestead</td>
</tr>
</tbody>
</table>

Source: Ensermu Kelbessa et al., 2000

Arundinaria alpina grows at altitudes ranging from 2,290-4,000 m a.s.l. on high mountains, hills and plains in the form of pure or mixed stands. The mean annual temperature of the area where this species grows is between 12-20°C and the mean annual precipitation is about 1,700-2,200 mm per year. The average stocking of this species is about 6,000 culms/ha. The average biomass of the culms is estimated to be about 51.3 t/ha with annual increment of 8.5 t/ha oven-dry culms. Highland bamboo stands outside forests, mostly growing on farmsteads, are a major source of raw material for furniture makers. Indeed, about 80% of all raw highland bamboo for furniture makers comes from farmers homestead plantation. However, there is no sufficient inventory for bamboo stands on farmers homestead.

The density of bamboo growth can vary from place to place based on the site conditions and extent of disturbance. Even aerial photos can only discern large disturbed areas where the bamboo grows densely. Past attempts at estimating Ethiopian
(Anonymous, 1997) and merely estimated the distribution of bamboo in four regions where bamboo occurs significantly. According to this report, one million ha of land is covered with different densities of bamboo growth (dense, sporadic and widely scattered) (Anonymous, 1997). It is important to note that figures given in this report cannot be used as representative of homogenous density for industrial use of Ethiopian bamboo forest. At present, not enough bamboo plantations exist in Ethiopia to supply any kind of mechanized industry.

Newly introduced bamboo species in Ethiopia

In 2007, ten Asian origin bamboo species were introduced into the country from Kenya under the East African Bamboo Project. These species included:

1. *Bambusa balcooa*
2. *Bambusa tulda*
3. *Bambusa vulgaris var. striata*
4. *Bambusa vulgaris var. green*
5. *Dendrocalamus asper*
6. *Dendrocalamus brandisii*
7. *Dendrocalamus hamiltonii*
8. *Dendrocalamus membranaceus*
9. *Phyllostachys pubescens*
10. *Guadua amplexifolia*

The objective of importing these species was to create species diversification within the indigenous bamboo growing areas and to establish bamboo plantations in areas where indigenous species could not grow. However, most of these species were disseminated to the farmers before the completion of the trial research.

There is lack of reliable information on our bamboo resources. Hence, there is now an urgent need to establish accurate inventories and to conduct comprehensive data collection. Reference is still being made to results of a study undertaken on Ethiopia’s bamboo resources 14 years ago (Anonymous, 1997). Data collection and inventories of our bamboo resources should be undertaken by integrated group of professionals from different agencies of regional state bureaus.

The participation of different agencies and professionals should play an important role in generating high quality data and information at the national level.
Potential contributions of bamboo to the national economy

In Ethiopia, the economic potential of bamboo has not yet been explored and the role of bamboo resources in the national economy is negligible. However, bamboo plays an important role in the ecology and biodiversity conservation of the country.

1. Bamboo for soil and water conservation

- Bamboo has unique morphological characteristics that can help conserve soil and water. Its underground root system, thick canopy and litter on the ground make bamboo an important resource in conserving soil and water more than any woody species. Bamboo consists of three morphological parts namely, the aerial part (the culm) and two underground parts (the rhizome and root). The underground root system is a very important structure for water and soil conservation. Due to the scarcity of seeds, bamboo is generally propagated by vegetative methods. The rhizome can be divided into three divergent forms viz, running (monopodial), clumping (sympodial) and metamorph (amphipodial).

Bamboo is a soil conservation tool; its anti-erosion properties create an effective watershed, stitching the soil together along fragile riverbanks, deforested areas, and in places prone to earthquakes and mudslides. The bamboo rhizomes are often so tightly packed that the soil under the bamboo plant seems to be filled with them. They form a 'turf' similar to ordinary grasses, which can vary in depth, depending on the species and growing conditions, although seldom deeper than 1 m (Recht and Wetterwald, 1992). Bamboo can form dense mass of underground rhizomes and roots on the contour. These act like reinforcing steel in concrete, protecting the soil under the plant from forming gullies.

2. Bamboo for protective function

Establishment of bamboo plantations and management of natural bamboo stands would help reduce deforestation which is one of the main causes of land degradation in Ethiopia. Due to its fast-growing characteristics, rapidly renewing itself, well-structured rhizomes and roots can bind the soil and help rehabilitate degraded lands within a few years. Bamboo has also the fastest growing canopy for re-greening
degraded areas and it generates more oxygen than an equivalent stand of trees. It lowers light intensity, protects against ultraviolet rays and is an atmospheric and soil purifier. Bamboo has many advantageous properties. Bamboo grows much faster than timber and requires less intensive management and expertise. It also naturally regenerates easily (Zehu, 2007).

3. Bamboo forest for carbon storage

Bamboo can be a suitable plant to combat global warming like other woody species in terms of carbon sequestration capacities, but unlike woody species it is not yet a part of Clean Development Mechanism projects. Its unique growing capacity makes bamboo a valuable sink of carbon; the underground bamboo biomass makes up to 25% to 50% of total stock content comprising usually about 50% of the total biomass. Bamboo biomass and carbon production is 7% -30% higher compared with any fast-growing woody species. Tropical bamboo species has been measured to have a total above ground biomass of around 47.8 t/ha/year (Lou and Lobovikov, 2007). The total biomass of mature bamboo at six years is higher than that of teak (Tectona grandis) at 40 years: 149 C/ha versus only 126 C/ha for teak. Besides a higher biomass, bamboo has also other advantages over woody plants as carbon stock. Unlike woody species, bamboo offers the possibility of annual selective harvesting and removal of about 15-20% of the total stock without damaging the environment and stock productivity. Over 90% of bamboo carbon can be sequestered in durable products such as boards, panels, furniture and activated charcoal. These products have a very long life span and may retain carbon for several decades (Lou and Lobovikov, 2007).

4. Bamboo forest for beautifying the environment and tourism

Bamboo has ever-green leaves, a fine shaped canopy and tall straight culms which are attractive to the eyes. Due to this, in many developed countries bamboo botanical gardens, bamboo parks and bamboo villages are established for tourism purposes and beautifying the landscapes of recreational areas. In these gardens and parks many species of bamboo have been collected; entertainment and relaxation places have been opened which can be used for scientific and recreational purposes. Furthermore, bamboo can also be used to produce a great number of commodities. A well-managed bamboo can be used for various purposes as indicated below:
a. Bamboo shoots as food

Bamboo shoots are young, new canes that are harvested for food before they are two weeks old or about 30-40 cm tall. Bamboo shoots are crisp and tender, comparable to asparagus, with a flavor similar to corn. They are frequently used in Asian cuisine. Commercially canned bamboo shoots are common but fresh, locally grown bamboo has far better flavor and texture. Currently, boiled and dried bamboo shoots processing industries are developing in Southeast Asian countries. For example, the Chinese bamboo shoot processing industries are annually exporting bamboo shoots worth around USD 200 million to Japan and European countries (Zehu, 2007).

Bamboo shoots contain several nutritive substances that the human body needs such as carbohydrates, proteins, fat, fiber and many inorganic nutritious substances and vitamins A, B and C as well. Fresh shoots generally contain 88-93% water, 1.5-4% protein, 0.25-0.95% fat, 0.78-5.86% total sugar of which 0.44-2.9% is soluble sugar, 0.60-1.345% is cellulose and 0.66-1.21% is ash (Zehu, 2007).

b. Traditional house construction

Bamboo has a variety of uses ranging from its use in building houses, pulp and paper manufacture, to cottage industries and household use. Bamboo is becoming more and more a farm crop in addition to being a major forest product. The principal users of bamboo are the rural poor. Traditionally, bamboo has been widely used for the construction of houses, as fuel, fodder, beehives, hats, mats, baskets, handicrafts, small furniture and other countless products in Ethiopia. Bamboo is used for making roofs and walls of traditional houses in Sidama and Asosa. In some areas like Sheka/Masha, very strong and straight A. alpina culms are used for beams and support poles (Ensermu Kelbessa et al., 2000).

In the countryside, farmers are utilizing bamboo for construction of walls and ceilings in the form of bamboo splits woven into a kind of mat for their round houses and linked enclosures.

c. Furniture making

The production and use of bamboo furniture has a long history in many countries. Currently, several craft shops are producing furniture made from bamboo in Addis Ababa, Hawassa and Bahir Dar. All craft shops use highland bamboo for their products. O. abyssinica which is more abundant than A. alpina is rarely used by craft shops.
These small-scale workshops are producing tables, couches, chairs, vases and various other products. The qualities of their products are low and not competitive with other materials in the market. Almost all products produced in all workshops are easily attacked by bio-deteriorating agents, have weak joints, are not well varnished or wear within a short time and have short service life. This may be happening due to lack of knowledge of the natural structure of bamboo and attempting to apply wood working methods unsuited to bamboo (Seyoum Kelemwork, 2006).

d. For bamboo-based panel boards and pulp/paper
The use of bamboo in many Asian and Pacific countries has expanded to manufacturing various commercial structural composite panels such as pulp and paper, oriented strand board (OSB) particleboard, fiberboard and laminated bamboo composites (Seyoum Kelemwork et al., 2007). Ethiopian bamboo may also be used as platform for trucks, floor underlayment, stair risers, sheathing panels, countertops, shelves, sink tops, tabletops, cabinets, table tennis tops, and different types of furniture (Seyoum Kelemwork, 2009). However, there is only one bamboo-processing factory in Ethiopia that produces bamboo floor boards, bamboo curtain, incense stick and toothpick.

e. Bamboo charcoal, active carbon and bamboo vinegar
Bamboo charcoal, active carbon and bamboo vinegar are new products developed in recent years. Due to special microstructure of bamboo, charcoal and active carbon produced from bamboo is used in the areas of high technology and industries. Bamboo charcoal products may be utilized in the following areas (Zhang et al., 2001) for i) purifying water; ii) purifying air; iii) absorbing unpleasant odors; iv) medicinal values or health care; v) refining coarse sugar; vi) refining wines of high grade and edible oil, antibiotics, vitamins and sulfanilamide, and removing pigments and impurities. It can also be used in agriculture to promote nitrogen fixation.

Challenges of bamboo resource utilization
Ethiopian bamboo resources are faced with the following challenges:

- Absence of policy and strategic planning process with respect to bamboo resources;
- Non consideration of bamboo as a high priority resource as it takes secondary place after timber which has been considered a high value commodity for long time;
• Existing institutional arrangements of the regional governments does not support bamboo development and utilization;
• Absence of a large-scale pulp/paper, laminated bamboo lumber and mat board processing factories in the country, which can help expand bamboo plantation;
• Bamboo growing areas have poor infrastructure (many bamboo growing areas have still remained underdeveloped and disconnected from the major market centres);
• Pre-processing workshops are not established around bamboo potential areas (craft shops are not centered in areas where bamboo is abundant);
• Lack of research on silviculture, propagation methods, stand management and frequency of flowering of the two species of Ethiopian bamboo;
• Lack of research on basic properties and industrial utilization of the two bamboo species;
• Degradation and loss of bamboo forests continue rapidly because of increased pressure from a) population growth and associated land use change, b) unregulated settlement and investment ventures, and c) shifting cultivation - the conversion of bamboo forest into large-scale crop production;
• Fire/burning bamboo stands (for O. abyssinica) drives the degradation of bamboo resources; and
• Lack of entrepreneurial spirit in the industry and obsolete and poor equipment in bamboo processing sector.

Recommendations

• There is an urgent need for accurate inventories to set bamboo resource policies.
• Private and collective-owned semi-mechanized craft shops should be organized around bamboo potential areas to invigorate the rural economy and take advantage of bamboo resources.
Forum for Environment (FfE)

FOREST TYPES IN ETHIOPIA

- Large-scale bamboo processing factories should be established near bamboo potential areas.
- Large bamboo plantations should be established to supply raw material for mechanized industries.
- More sophisticated craft techniques should be introduced from Asia-Pacific countries.
- Separate research centre should be established specifically for bamboo.

References


COMBRETUM-TERMINALIA
BROAD-LEAVED DECIDUOUS FORESTS

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Introduction

Woodlands (most parts of which are now regarded as forests) and bushlands cover 55 million ha (48.6%) in Ethiopia (WBISPP, 2004). These vegetation resources comprise various vegetation formations among which the Combretum-Terminalia broad-leaved deciduous and Acacia-Commiphora narrow-leaved deciduous forests are the two dominant types. These are primarily found in the lowlands, often called ‘pastoral zones’ in the northwest, west, northeast, east, south, southwest, along the Rift Valley and major river gorges. The focus of this paper is on Combretum-Terminalia woodlands hereafter referred to as Combretum-Terminalia broad-leaved deciduous forests.

These forests provide important products and services for local communities as well as the national economy. Moreover, different Acacia species that yield gum and Boswellia papyrifera (Del.) Hochst that yield olibanum are economically important tree species found in this vegetation (Mulugeta Lemenih and Demel Teketay, 2003). The collection of gums and resins in these areas create employment opportunities for large number of daily labourers and generate income for the government, particularly foreign currency for the country (Abeje Eshete, 2002; Mulugeta Lemenih and Demel Teketay, 2003).

Combretum-Terminalia forests possess the following typical characteristics:

- Small to medium trees with fairly large deciduous leaves (often occur with lowland bamboo);
- The understory is a combination of herbs and grasses - usually herbs dominate the ground layer at the beginning of the rainy season while grasses dominate towards the end of the rainy season; and

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The vegetation has developed under the influence of fire. Thus, trees have very thick bark to cope with fire while most herbs have perennial bulbs (they are geophytes).

The objective of this paper is to summarize literature review as well as the authors’ long years of research experience in dryland forestry to bring to light available ecological and socio-economic information on the Combretum-Terminalia broad-leaved deciduous forests. Challenges that have faced the forest resources have been well-captured and recommendations have been forwarded.

Geographical distribution and environmental attributes

Combretum-Terminalia broad-leaved deciduous forests occur mainly in the northwestern, western and southwestern parts of the country (Figure 1). Regionally, it exists in Tigray, Amhara, Benishangul Gumuz, Gambella, Oromia and SNNPR. It penetrates into the valleys of rivers in the southern and southwestern, and western drainage systems such as the Didessa, Baro, Omo, Abay, Tekeze, Anger and others. The Combretum-Terminalia broad-leaved deciduous forests are also recognized in the rocky slopes of Dakota Valley between Harer and Jijiga, although very limited in terms of spatial coverage.

There are patches of this kind of forest between the Acacia-Commiphora narrow-leaved deciduous forests of the Rift Valley in southern Ethiopia and the dry evergreen forests, e.g. the escarpment (sometimes interrupted by low lying river valleys, but mostly on both sides of the Rift Valley) extending from Humbo south to the Omo valley, and making an ecotone between the Acacia-Commiphora narrow-leaved deciduous forest and moist and/or the dry evergreen montane forests extending eastwards from the escarpments in the Omo Valley to Magada, Shakiso and Jamjam forests in Sidamo floristic region and stretching east via Daio Mana to Ginir in Bale and Dakat Valley between Babile and Jijiga in Harerge. Of course, some remnant vegetation representing this forest type can be encountered in places like Ziway Dugda (Arsi side of Lake Ziway).
Legend

- Desert and semi-desert scrubland (DSS)
- Acacia Commiphora woodland and bushland proper (ACB)
- Acacia wooded grassland of the Rift Valley (ACB/RY)
- Wooded grassland of the Western Gambela region (WGG)
- Combretum Terminalia woodland and wooded grassland (CTW)
- Dry evergreen Afromontane forest and grassland complex (DAF)
- Moist evergreen Afromontane forest (MAF)
- Transitional rain forest (TRF)
- Ericaceous belt (EB)
- Afroalpine vegetation (AA)
- Freshwater lakes - open water vegetation (FLV/OW)
- Freshwater marshes and swamps, floodplains and lake shore vegetation (FLV/MFS)
- Salt lakes - open water vegetation (SLV/OW)
- Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation (ALV/SSS)

Figure 1 Vegetation types of Ethiopia including the vegetation in the ASALs (note that two vegetation formation covers the vast part of Ethiopia: Acacia-Commiphora in the east, southeast, northeast and the vast stretch of Combretum-Terminalia broad-leaved deciduous forest along the western part of the country stretching all the way from north to south; modified slightly from Friis et al., 2010)

Combretum-Terminalia broad-leaved deciduous forest occupies the altitudinal range between 400-500 and 1,900 m a.s.l. The environments of these forests are characterized by high temperature and relatively good rainfall. The second highest mean maximum temperature of the country was recorded in the western lowlands of Ethiopia (35-40°C), an area where the Combretum-Terminalia broad-leaved deciduous ecosystem occurs, next only to that of the Afar Depression, an area where the Semi-desert and Desert ecosystem type occurs.

The geology of the Combretum-Terminalia broad-leaved deciduous ecosystem is characterized by extensive Late Tertiary that covers the pre-Cambrian rocks that underlie all the other rocks in Ethiopia (Mohr, 1971). Old crystalline rocks overlay the pre-Cambrian rocks in the relief down to Sudan and valleys are largely composed of Phyllite with uncommon Chlorite Schist (Mohr, 1971).
The soils of their environment are varied but foot slopes and plains are characterized mainly with Chromic and Pellic Vertisols, while areas experiencing frequent flooding often possess Eutric Glysols and Eutric Histosols. Hill sides are shallow type Lithosols, Cambisols and Regosols. In some of the areas with high rainfall such as lowlands of Didessa, Anger and Baro highly weathered soils such as Feralsols or their associate predominate.

Wood species composition and density

Although the composition of woody species varies from site to site, studies in four different sites show that up to 16 families and 35 species can be observed in Combretum-Terminalia broad-leaved deciduous forests (Table 1). The dominant life form among these are trees followed by shrubs and then woody climbers. The most frequent families are Fabaceae and Combretaceae. The most frequent species are Boswellia papyrifera, Lannea sp. Terminalia glaucescens, Anogeissus leiocarpa, Combretum hartmanniana, Acacia sp., Sterculia setigera and Ziziphus abyssinica. Stem density per hectare also varies from site to site and ranges from as low as 250 stems/hectare to as high as over 1,000 stems/hectare (Sisay Asfaw, 2006; Alemu Biresaw and Pavlis, 2010). Some of the economically important species such as Boswellia pirottae and B. papyrifera have been classified as threatened species (WCMC, 1998).
Table 1 List of some tree and shrub species recorded from Combretum-Terminalia broad-leaved deciduous forests in western Ethiopia

<table>
<thead>
<tr>
<th>Species</th>
<th>Family name</th>
<th>Growth form</th>
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<tbody>
<tr>
<td>Acacia nilotica (L.) Willd. ex Del.</td>
<td>Fabaceae</td>
<td>Tree</td>
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<tr>
<td>Acacia polycantha Willd.</td>
<td>Fabaceae</td>
<td>Shrub/tree</td>
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<tr>
<td>Acacia senegal (L.) Willd.</td>
<td>Fabaceae</td>
<td>Shrub</td>
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<tr>
<td>Acacia seyal Del.</td>
<td>Fabaceae</td>
<td>Shrub/Tree</td>
</tr>
<tr>
<td>Anogeissus leiocarpa (A. DC.) Guill. &amp; Perr.</td>
<td>Combretaceae</td>
<td>Shrub/tree</td>
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<tr>
<td>Boswellia papyrfera Del. Hochst.</td>
<td>Burseraceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Boswellia pirottae Chiov.</td>
<td>Burseraceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Cissus populnea Guill. &amp; Perr.</td>
<td>Vitaceae</td>
<td>Lianas</td>
</tr>
<tr>
<td>Combretum collinum Fresen.</td>
<td>Combretaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Combretum hartmanniana Schweinf.</td>
<td>Combretaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Combretum molle R. Br. ex G. Don</td>
<td>Combretaceae</td>
<td>Tree</td>
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<tr>
<td>Combretum molle R. Br. ex G. Don</td>
<td>Combretaceae</td>
<td>Shrub/tree</td>
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<tr>
<td>Ficus sycamorus L.</td>
<td>Moraceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Ficus thonningi Blume.</td>
<td>Moraceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Species</td>
<td>Family name</td>
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<tr>
<td>Flueggia virosa (Willd.) Voigt.</td>
<td>Euphorbiaceae</td>
<td>Shrub</td>
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<tr>
<td>Gardenia ternifolia Schum. and Thonn.</td>
<td>Rubiaceae</td>
<td>Shrub/tree</td>
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<tr>
<td>Grewia bicolour Juss.</td>
<td>Tiliaceae</td>
<td>Shrub/tree</td>
</tr>
<tr>
<td>Grewia ferruginea A. Rich.</td>
<td>Tiliaceae</td>
<td>Shrub/tree</td>
</tr>
<tr>
<td>Grewia trichocarpa Hochst.ex ???</td>
<td>Tiliaceae</td>
<td>Shrub/tree</td>
</tr>
<tr>
<td>Opterocarpus lucens Guill. and Perr.</td>
<td>Fabaceae</td>
<td>Shrub/tree</td>
</tr>
<tr>
<td>Oxytenanthera abyssinica A. Rich.</td>
<td>Gramineae</td>
<td>Grass</td>
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<tr>
<td>Ozoroa insiginis Del.</td>
<td>Anacardiaceae</td>
<td>Tree</td>
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<tr>
<td>Sterculia setigera Del.</td>
<td>Sterculiaceae</td>
<td>Tree</td>
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<tr>
<td>Stereospermum kunthianum Cham.</td>
<td>Bignoniaceae</td>
<td>Tree</td>
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<tr>
<td>Strychnos heningsii Gilg</td>
<td>Loganiaceae</td>
<td>Tree</td>
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<tr>
<td>Terminalia glaucescens Planch. ex Benth.</td>
<td>Combretaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Terminalia glaucescens Planch. ex Benth.</td>
<td>Combretaceae</td>
<td>Tree</td>
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<tr>
<td>Ziziphus mucronata Willd.</td>
<td>Rhamenaceae</td>
<td>Tree</td>
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<tr>
<td>Cheleqeleqit*</td>
<td>NI</td>
<td>Shrub/tree</td>
</tr>
<tr>
<td>Dafent/Joro-kukoba*</td>
<td>NI</td>
<td>Shrub</td>
</tr>
<tr>
<td>Hameja*</td>
<td>NI</td>
<td>Tree</td>
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<tr>
<td>Species</td>
<td>Family name</td>
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<tr>
<td>Shutera*</td>
<td>NI</td>
<td>Shrub/tree*</td>
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<tr>
<td>Wonebela*</td>
<td>NI</td>
<td>Tree</td>
</tr>
<tr>
<td>Workina*+</td>
<td>NI</td>
<td>Tree</td>
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</table>

NI=Local names for species which were not identified; *only seedlings were found and could not be possible to categorize it either as tree or as shrub. This category was given by farmers. NI= not identified (Source: Sisay Asfaw, 2006; Alemu Biresaw and Pavlis, 2010; own observation).
Regeneration status

Although comprehensive assessments are lacking, dry forests of Ethiopia in general and Combretum-Terminalia broad-leaved deciduous forests in particular are characterized by poor regeneration and abnormal population structure for most of the species. Human caused disturbances such as forest grazing and fire are widespread and significant and in most cases, negatively affecting their regeneration. However, regeneration responses of plant communities and species to disturbances vary. Indeed, considerable inter-species variations are observed in response to disturbances.

Particularly, species like Boswellia papyrifera, the most economically important species in the Combretum-Terminalia broad-leaved deciduous forests, is showing very poor regeneration pattern (Kindeya Gebrehiwot, 2003; Abeje Eshete et al., 2005; Sisay Asfaw, 2006; Mulugeta Lememih et al., 2007; Aklilu Negussie et al., 2008; Abrham Abiyu et al., 2010). The major population bottleneck of this species is not seedling emergence but high mortality and even when protected against grazing and fire the seedlings fail to exhibit good survival (e.g. Aklilu Negussie et al., 2008). A comparison of regeneration assessment made during dry season and wet season shown in Figure 2 is an excellent example of the high seedling mortality for the species. Large seedling population emerges during the rainy season, but almost all die during the successive dry season (Aklilu Negussie et al., 2008).

Figure 2 Population structure of B. papyrifera from Metema district (wereda) during a) dry season, b) rainy season
The study by Sisay Asfaw (2006) that assessed the regeneration of the "woodlands" under combination of anthropogenic disturbance regimes such as burning and grazing also provides good clues on how these forests respond to anthropogenic disturbances. According to the findings, the diameter class distribution of the entire woody species at three sites that represent three disturbance regimes (BUG - Burnt but ungrazed; BG - Burnt and grazed and UBG - Unburnt but grazed) all showed a sort of inverted "J-shape" that indicate a normal or healthy population (Figure 3a).

The same was true for 20 commonly occurring species in all sites. However, in both cases there is an immediate and sharp decline from the seedling class (<5 cm class) to the next class that shows high seedling mortality and low recruitment. The rate of decline is very fast for plots under BUG followed by BG sites. The population structure of Boswellia papyrifera showed high seedling population for BG and BUG than UBG sites, which shows that probably mild burning encourages seedling emergence. However, as shown in Figure 2, the result in Figure 3c also reveal a sharp drop of the frequency from seedling class to the next showing the survival of very few seedlings for recruitment into the next generation. This problem of B. papyrifera has been observed from other countries like Eritrea and the Sudan (Woldesilasee Ogbazghi, 2001; Abuelgasim and Abdalla, 2008).

![Figure 3 Population structure of the woody species based on diameter-class distribution: (a) for all woody species encountered in the study in all sites (Source: Sisay Asfaw, 2006)](image-url)
Figure 3 Population structure of the woody species based on diameter-class distribution: b) for the twenty commonly occurring species in all sites, and (c) for Boswellia papyrifera (Source: Sisay Asfaw, 2006)
Socio-economic uses

The traditional land use in this forest type is shifting cultivation, hunting and gathering. Shifting cultivation is a hoe-based small-scale practice that involves sorghum and finger millet. Consequently, the ecosystem has not been hosting agricultural practices for long. Further, unlike the Acacia-Commiphora narrow-leaved deciduous forests that are extensively used for pastoral and agro-pastoral production systems, cattle husbandry in Combretum-Terminalia broad-leaved deciduous forest ecosystems is very low. People traditionally grow sorghum, sesame and cotton. This is because of two reasons. First, the prevalence of tsetse flies, a vector for the animal disease, trypanosomiasis. Second, the highest prevalence of malaria that prevents large-scale human habitation. Until few decades ago the Combretum-Terminalia broad-leaved deciduous forests were therefore occupied by few and diverse ethnic minorities (Berihun Mekonnen, 2004; 2009).

Nonetheless, the trend in recent decades has shown an unprecedented scale of immigration from highlands to the Combretum-Terminalia broad-leaved deciduous forests both through officially sponsored resettlement programme as well as spontaneously (Behailu Kebede, 2006; Tesfaye Tafesse, 2009; Mulugeta Lemenih et al., in press). Immigration (resettlement) has caused and is causing large scale deforestation and degradation of the "woodlands" (Behailu Kebede, 2006; Mulugeta Lemenih et al., 2007; Tesfaye Tafesse, 2009, Mulugeta Lemenih et al., in press). For instance, in Metema district of North Gonder Zone of Amhara Region, between 1972 and 2005, about 17.2% of the forests in the district, an area equivalent to 64,934 ha, was converted into croplands, while 5,975 ha have been converted to settlements. The favorable biophysical environment of the forests for cash crops such as sesame and cotton is attracting not only small holder farmers but also large agri-business investors that are intensifying the conversion of the ecosystem.

In some of the areas such as parts of Tigray and Amhara regions, Combretum-Terminalia broad-leaved deciduous forests are largely used as transhumance grazing sites. They are the main destination for seasonal movement of large herds/flocks from the neighbouring highland districts. For instance, a study by Azage Tegegne et al. (2009) revealed that out of the total number of cattle population in the three nearby highland districts, 60.3% are trekked to the lowlands during the rainy season, and that the trend of transhumance to the lowland is increasing due to feed shortage, expansion of crop cultivation and increasing cattle population in the highlands.
Combretum-Terminalia broad-leaved deciduous forest provides diverse products and services to the inhabitants. They provide a source of food (forest foods), honey, medicinal plants and wood for fuel and construction. The most economically important forest products obtained from the Combretum-Terminalia broad-leaved deciduous forest are perhaps frankincense and gum arabic. The vegetation mostly hosts B. papyrifera, a renowned source of white frankincense, and also Acacia Senegal, a renowned source of gum arabic. The white frankincense - also called Tigray type frankincense dominates production and trade in Ethiopia. It accounts for 90% by volume of exported gum-resins from the country (Mulugeta Lemenih, 2005).

Thus, nationally it is the most economically important product obtained from the Combretum-Terminalia broad-leaved deciduous forests. Local level socio-economic importance of frankincense production varies considerably depending on cultural, economic as well as biophysical endowments of the producing areas. In central Tigray, where the biophysical environment is more arid and other livelihood activities are constrained, frankincense production has been playing a significant income diversification role.

In other areas such as Humera, all western districts (weredas) of the Amhara Regional State and Benishangul Gumuz, local people’s engagement is very much restricted with almost no economic benefits from it. Because the biophysical environment in these areas is conducive for cash crops such as sesame and cotton as well as for livestock husbandry, local people are more engaged in these activities for livelihood rather than tapping the frankincense. In these latter areas, gum companies (para-state or private) are producing frankincense often using external labours.

Tree species in Combretum-Terminalia broad-leaved deciduous forests, for instance, Combretum molle, also provide diverse products as shown below (Orwa et al., 2009):

- **Fodder**: The leaves are browsed by cattle.
- **Apiculture**: Flowers attract bees and make good forage for honey production.
- **Fuel**: Wood burns slowly, giving intense heat, and is suitable for firewood and production of high quality charcoal.
- **Timber**: Combretum wood is yellow, hard, coarse, brittle when dry and rots easily. It is said to be reasonably termite-resistant and is suitable for implement handles, poles, stools, construction and fence posts.
• Tannin or dye stuff: A red dye can be obtained from the leaves and yellow dye from the roots.
• Medicine: Boiled root decoction is used to induce abortion and treat constipation, leprosy, headaches, stomach pains, fever, dysentery, general pains, swellings and as an anti-helminthic for hookworm. The roots and leaves together are believed to be an antidote for snake bite; leaves are chewed or pounded, soaked in water and the juice drunk for chest complaints and as an anti-helminthic or are used as an inhalant in hot steam bath. An infusion of the inner bark is taken orally or as an enema to relieve various stomach ailments. The bark exudes a gum that can be used to treat wounds, or crushed dried or fresh leaves can be used for the same purpose.
• Soil improver: Leaf fall is a source of mulch and green manure for the soil.

Challenges to Combretum-Terminalia broad-leaved deciduous forests

A number of factors mostly socio-economic and policy/institution are affecting the use and management of Combretum-Terminalia broad-leaved deciduous forests. Some of these factors are proximate (direct) and others are underlying. The proximate factors include: clearance for agriculture by both small holders and agribusiness investors; over grazing (local plus transhumance), forest fire and excessive harvest of wood for construction and firewood. The underlying factors include population growth mainly due to immigration (spontaneous as well as sponsored resettlement) and policy constraints.

Population growth

One of the major causes of forest degradation of Combretum-Terminalia broad-leaved deciduous forests in Ethiopia is population growth. Population grows mainly due to large immigration from spontaneous as well as planned government sponsored resettlement programmes (Behailu Kebede, 2006; Mulugeta Lemenih et al., 2007; Mulugeta Lemenih et al., in press). Population growth affects Combretum-Terminalia broad-leaved deciduous forests in many ways. Resettlement is one of the policy options practiced by the Ethiopian governments, previous and current, to tackle the problem of land degradation and food insecurity in the highlands. In recent years, resettlement programme is widely practiced and most of the recent resettlement practices, which are region based, are mainly affecting the lowlands where the remaining dry forests of the country are situated.
However, the subsequent interactions between the dry forests and the resettlers, and the impact caused on dry forest (degradation or development) are largely unaccounted for, at least up to now. In fact, the sustainability of resettlement scheme in achieving food security depends on a combination of factors, the ultimate yardstick being the extent to which resettlers adapt to their new environment, without repeating the same environmental damage, which was a cause for their displacement.

Studies from different dry forest areas that hosted resettlement have shown significant degradation of forests. In Metema district, a recent study shows that large-scale deforestation is associated with the arrival of settlers from the highlands during the last four decades. Annual rate of cropland expansion between 1972 and 2007 was 0.49% or 1,855.3 ha/yr (Kassaye Emrie and Enatagegnehu Tarekegn, 2010). Similarly in Pawe, Behailu Kebede (2006) showed that bare and grass lands increased 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. Agricultural land/settlement increased by 6,876.5 ha (18.3%) over 15 years period.

Population growth, whether natural or through legal and illegal settlement affects dry forests in several ways: First, clearing of the Combretum-Terminalia broad-leaved deciduous forests for cropland expansion, which is among the major threats to the vegetation. Taking Metema district as a case, the total population is estimated currently at 78,741. Among these, the natives (Gumuz community) make up only 2%. Thus, 77,141 individuals are migrants of one or another form. Furthermore, between 1995-1998 E.C. about 18,586 household heads have been officially settled in Metema district through Amhara Regional State Resettlement programme. Considering the official land allocated for the settlers in the district, which is 2.0 ha per household, then a minimum area of 37,172 ha of Combretum-Terminalia broad-leaved deciduous forest has been converted to agriculture in just four years. In general, estimates show that nearly 303,180 ha of forests in Metema district have been converted into agricultural land in just 30-35 years (see also Plate 1). Similarly, in Tigray Region more than 177,000 ha of Boswellia forest has been reported to be destroyed in the last 20 years (Kindeya Gebrehiwot, 2003).

Second, impacts from settlement on Combretum-Terminalia broad-leaved deciduous forests are also through wood harvest for various purposes (Plate 2) such as construction of houses, firewood and charcoal for home and sale, fencing, etc. For instance, the information obtained from Metema district showed that on average construction of a hut consumes 150 wood and 180 bamboo culms.
Plate 1 Agricultural fields in the midst of Boswellia forest in Metema district (Photo: Mulugeta Lemenih)

Plate 2 Resettlement and its impact through tree cutting for housing, firewood and fencing (Photo: Mulugeta Lemenih)
There are several policy constraints that directly affect and are affecting the Combretum-Terminalia broad-leaved deciduous forests in Ethiopia. These policy constraints are: resettlement programme, the crop focused rural development strategies and weak forestry sector institutional set up. State-sponsored resettlement programmes have been implemented by successive governments including the present since the 1960s (Belay Kassa, 2004; Hammond, 2008). Destinations of most resettlers were both northwestern lowlands such as Pawe, Metema, Quara and Humera as well as southern highlands and lowlands, most of which are Combretum-Terminalia broad-leaved deciduous forests (e.g. Reid et al., 2000; Behailu Kebede, 2006; Tesfaye Tafesse, 2009; Mulugeta Lemenih et al., in press). Particularly, since the resettlement programme has been launched by the present government in 2003, most destinations have been the Combretum-Terminalia broad-leaved deciduous forests which has speeded up and intensified their degradation (e.g. Mulugeta Lemenih et al., 2007; Kassaye Emrie and Enatagegnehu Tarekegn, 2010; Mulugeta Lemenih et al., in press). According to the study by Kassaye Emrie and Enatagegnehu Tarekegn (2010) in Metema district, cropland expanded from 30,725 ha in 1972 to 95,659 ha in 2007, which is at an approximate annual rate of 1,855.3 ha.

The presence of formal regulatory mechanism to ensure regulated access to and use of forest resources is critical. Though in principle there are designated offices to do so, in practice no local government authority is managing the forest resource in Metema district. For instance, the study of Mulugeta Lemenih et al. (in press) in Metema district reports that 66.1% of respondent households interviewed believed that the current forest management system is absolutely insufficient. Furthermore, about half of the respondents do not know the legally responsible regulatory bodies in the district to manage the forest (which by law are the District Office of Agriculture and the local or Kebele Administration). In this regard, experts of the District Office of Agriculture also recognize that it remained incapable of discharging its duties and responsibilities. They identified the absence of a management plan to assist sustainable management of the forest, poor technical knowledge, and insufficient staff and logistic capacity as major constraints. In the absence of effective regulatory frameworks, open access becomes a trend, with all its potential negative consequences. However, this open access created in the case of the forests in Metema clearly indicates that ‘tragedy of the commons’ results not necessarily from an inherent failure associated with a common pool resource nor from the mere increase in population due to migration but from institutional failures (indigenous or formal) to control access to natural resources.
The Combretum-Terminalia broad-leaved deciduous forests in western and northwestern Ethiopia are also destroyed due to commercial agricultural investment. Under the pretext of establishing modern farms, some investors have cleared forests, sold firewood, charcoal and timber for construction without making any investments. After the investors make money from the sale of forest/wood products, they cultivate the land for one or two seasons and then abandon the area. This has become a very serious threat to the forest biodiversity mainly in primary forest areas of the south, southwest and western parts of the country.

Land leasing agreements need to eliminate such loopholes which end up in unfairly enriching "smart investors" at the expense of the local people and their biodiversity. If the agreements are not able to eliminate this trend, rather than attaining the objective the lease is intended for, which is promoting agricultural development that can contribute to the overall growth of the nation, they will continue to damage the environment. The leasing agreement should particularly include the payment for the resource on the land and penalties for those who quit without adequate justification before the time stipulated in the agreement (IBC, 2009; 2010).

Overgrazing

Despite the marginal environmental conditions for living and farming, semi-arid and arid lowlands where oleo-gum resin producing plants dominate are under increasing human pressure in Ethiopia. The lowlands, above all, offer high livestock production potential due to their lush grass resources. The Combretum-Terminalia broad-leaved deciduous forests and bushlands are largely situated in the agro-pastoral and pastoral zones where they support large livestock population (Plate 3). The animals are allowed to graze freely in all types of forests without restriction on numbers or seasons. Moreover, highlanders also send their cattle temporarily for summer period grazing when the highlands are fully under crop cultivation. Consequently, the ecological disturbance and damages caused by overgrazing, particularly the negative impacts on natural regeneration of woody species, including gum resin producing vegetation is immense (Abeje Eshete, 2002; Azage Tegegne et al., 2009).

Dryland forests are inhabited mainly by pastoral and agro-pastoral population. They often host the largest population of livestock per head. The traditional system of free grazing with such large number of livestock is a problem to sustainable gum production in the area (Plate 3).
Change of life style from nomadic to semi-permanent or permanent settlement, which is encouraged by population pressure, is also breaking the traditional and more or less sustainable system of Combretum-Terminalia broad-leaved deciduous forest management in several of the dryland areas. Consequently, large livestock populations are confined to small areas leading to severe vegetation and other ecological damages.

In most of the dryland forests, besides the fast growth of population of the native people, there is also a continuous influx of pastoralists from neighbouring countries (transhumance) mainly from Somalia, Kenya and the Sudan.

Plate 3 High livestock population in dryland forests of west (a) and south (b) causing overgrazing (Photo: Mulugeta Lemenih)

Forest fire

Traditional savannah and Combretum-Terminalia broad-leaved deciduous forest vegetation management involves fire, particularly by cattle herders and pastoralists (Plate 4). Though the vegetation in dryland areas are evolved under cyclic fire, some species such as B. papyrifera need some fire-free years to allow enough regeneration and the development of seedlings into saplings and poles to maintain the populations. However, in most cases Combretum-Terminalia broad-leaved deciduous forests are exposed to annual burning that is badly affecting not only delicate seedlings but also mature trees. Besides, tapped trees of B. papyrifera for example, are more easily affected by fire than untapped trees, since the resin oozing out of the trees is inflammable to cause intense fire and thus, tree death.
Plate 4  Fire intensity and damage in Metema district (Photo: Mulugeta Lemenih)

Specific problem for B. papyrifera species

Boswellia papyrifera is one of the two species of the genus Boswellia found in the Combretum-Terminalia broad-leaved deciduous forests with high socio-economic significance (Mulugeta Lemenih, 2005). However, the species is suffering significant population decline in recent years. Lack of regeneration and high rate of adult mortality are among the key bottlenecks for the species. Several studies have witnessed that young trees (seedlings and saplings) are consistently absent for the species in its natural environment.
Some studies report that 65% of the total stem of the population of the species falls in the diameter ranges of 13 – 15 and 16 – 24 cm. The low density of individuals in the lower diameter classes suggests that regeneration and new recruitment are lacking and that the population is under serious threat of unsustainable condition (Figure 4).

Figure 4 Population structure of B. papyrifera in Metema district, northwestern Ethiopia (Mulugeta Lemenih et al., in press)

Impediments to regeneration

1) Production of less quality and less quantity of seeds. Studies revealed that Boswellia trees produce less quality and quantity of seeds when intensively tapped (e.g. Woldesilasee Ogbazghi, 2001), which shows low regeneration rate. For instance, Woldesilasee Ogbazghi (2001) showed that these rates were about 14% compared to rates above 80% for seeds from untapped stands. Similarly, Abeje Eshete et al. (2005) showed that untapped trees yielded significantly higher viable seeds than continuously tapped trees. The same study showed that the effect of tapping is more pronounced on older trees than younger ones. Tapped stands also produce seeds with more insect attack (16.6%) and higher proportion of unfilled seeds than untapped stands. Therefore, tapping, by interfering with tree physiology, results in the production of high proportion of unfilled seeds and seeds that are liable to opportunistic predators. These seeds fail to produce seedling leading to the absence of natural regeneration.
ii) **Seedling damage due to overgrazing.** The second hypothesis for low regeneration is the effect from overgrazing. In all instances where impact of grazing was studied, seedling establishment was better in enclosed or fenced experimental plots than openly grazed sites. Seeds and seedlings of most of the gum and resin trees are vulnerable to grazing because (a) their seeds have epigeal growth, (b) the seedlings are succulent and palatable and are therefore preferred by livestock and wildlife for browse, and (c) the seedlings grow too slowly to escape grazers rapidly. In Eritrea, for instance, in three years time seedlings attained a maximum height of only 15 cm and basal diameter of 1.5 cm (Woldesilasee Ogbazghi, 2001). This elongated juvenile period increases the risk of being eaten, trampled or damaged. Another factor in this respect is fire, which can kill most seedlings.

iii) **Damage by fire.** Fire intensity and frequency has increased in most dryland areas due to increased influx of human population making the fires damaging than that occurring under natural occasions. The increased intensity is damaging the young succulent seedlings leading to their burn.

**Conclusions and recommendations**

Irrespective of its abundance, there are no resources that cannot be exhausted if unsustainably utilized. Sustainable utilization of resources has a big impact on the development of the nation in general and community in particular. Current system of utilization is almost near open access and thus unsustainable, while management of any type is almost absent. In order to keep the sustainability of Combretum-Terminalia broad-leaved deciduous forests and benefit the local people living in, near and around and the national economy these forests need to be conserved and managed sustainably. The following strategies should be taken into account for their sustainable management:

- Regulatory frameworks need to be strengthened, while strengthening and capacitating the forestry sector institutions with human and logistic resources.
- Reducing influx of migrants (sponsored or self) is an immediate action that should be taken.
- Constituting, monitoring and enforcing farm size ownership for residents are also immediate actions that ought to be implemented.
- Managing to enhance the natural course of regeneration of the poorly represented species (e.g. B. papyrifera) intervention is strongly recommended through artificial regeneration by direct planting, cuttings as well as protection.
In order to promote the important ecological functions of the forests, post-fire livestock management must allow resting period through which the vegetation recovers and escapes livestock damage. Since livestock is necessary due to productive reason in the study area, a reduction in stocking rates, at least during time lapes large enough for small individuals to reach sufficient height and vigor to reduce and escape damage by livestock browsing and trampling would be an acceptable option. Use of rotational grazing to distribute browsing influence in space and time and enhance seedling recruitment will be another option. Furthermore, there is a need to conduct research for determining rest period since it depends on the species involved and site factors.

Reduction of high intensity and frequent fire is needed, while maintaining prescribed burning as a management option. In this regard there is a need to study fire interval depending on the objective of setting fire.

Long term researches are needed to find the most efficient way to assist the recovery of degraded Combretum-Terminalia broad-leaved deciduous forest ecosystems.

Designing and promoting alternate means of forest conservation, such as establishment of protected or conservation areas need to be explored so as to preserve some of the valuable biological resources of the forests.

The principal issue for most communities is that there is no incentive to conserve. Farmers abandon conservation in favor of maximum exploitation for immediate economic gain. Therefore, giving communities a significant final portion of revenues generated from the land (e.g. from incense collection), would give them an incentive to use sustainable management of the resources without considerable policy changes necessary in order to transfer ownership of the land from the state to the people.

Transhumance mode of livestock production system has to be checked or there has to be a mechanism by which the two communities (those coming from the highland in search of grazing land and the local people) work together towards the sustainable management of the resource.

To halt the current rate of degradation, protecting the forest through guarding seems ineffective. Rather, organizing Community Based Organizations and working with them towards rational use of the forests would be appropriate.
References


Introduction

The vegetation cover of a given area has a definite structure and composition, which has developed as a result of the long term interaction between biotic and abiotic factors. The pattern of distribution and vertical stratification of vegetation fluctuates due to different climatic zones, soil types, latitude and topography of the area which in turn would influence the distribution and type of plants and animals in the forest (Mueller-Dombois and Ellenberg, 1974).

Ethiopia is found in the Horn of Africa and located between 3°24' and 14°53' North and 32°42' and 48°12' East with a total area of 1.12 million km² (MoA, 2000). The altitudinal range of the country varies from 110 m below sea level at Kobar sink in Afar to 4,620 m a.s.l., the highest peak of Ras Dejen (IBC, 2008). The highland plateau of Ethiopia with an altitude of above 2,500 m covers 40% of the country (EFAP, 1994; Demel Teketay, 1999; Zerihun Woldu, 1999). The Great East African Rift Valley bisects the plateau into western and eastern highlands. The uplands and highlands west of the Rift Valley are collectively termed as the northwestern highlands and the highland massifs east of the Rift Valley are termed as the southeastern highlands.

The topography and diverse climatic conditions of Ethiopia led to the creation of habitats that are suitable for evolution. These have led to the occurrence of some unique plant and animal species and their assemblages. As a result, Ethiopia is one of the countries in the world with high level of biodiversity. Owing to the long history of agriculture and diversity of the environment, Ethiopia is again one of the 12 Vavilov centers of crop genetic diversity (Zerihun Woldu, 2008).

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Logan (1946) and Pichi-Sermolli (1957) provided the general outline of Ethiopian forest vegetation, comprising three distinct forest types: Montane Dry Evergreen Forest, Montane Moist Evergreen Forest and Arundinaria-Bamboo Forest. Von Breitenbach (1963), however, recognized more forest types according to their dominant species, and grouped them into two broad categories: Lower and Upper Highland Forests. The other surveys of Ethiopian forests are those by Friis et al. (1982) and Friis (1986; 1992). The monograph by Friis (1992) presents description of the forests and forest trees of northeast Africa, which are occurring in Ethiopia into seven.

According to the most recent studies conducted (Ensermu Kelbessa et al., 1992; Sebsebe Demissew et al., 1996; Friis and Sebsebe Demissew, 2001; Sebsebe Demissew et al., 2004; Sebsebe Demissew and Friis, 2009), the vegetation of Ethiopia is divided into eight major types: Desert and Semi-desert Scrubland, Acacia-Combretum-Terminalia Woodland, Moist Montane Forest, Lowland Semi-evergreen Forest, Combretum-Terminalia Woodland, Dry Evergreen Montane Forest, Afroalpine and Sub-Afroalpine Vegetation and Riparian and Wetland Vegetation.

**Status of forests in Ethiopia**

Although there are limited empirical evidence for the extent and cover of the Ethiopian forests, available literature indicates that some 35-40% of the land mass was covered by forest vegetation of varying types and density (EFAP, 1994). In the early 1950s, this coverage was reduced to about 16% of the landmass. In the early 1980s, the coverage was reported at 3.6%. By 1989, it was estimated to be only 2.7%. The loss of forest resources is severe in the Ethiopian highlands, above 1,500 m. These highlands cover about 44% of Ethiopia's land area but accommodate 88% of the total population and contain about 95% of the cultivated land. More than 67% of the national livestock herd is also concentrated here (EFAP, 1993).

**Dry evergreen montane forests**

**Description**

The prominent features of tropical dry forests are their seasonality with respect to rainfall compared with the rain forests where the environment is relatively stable throughout the year. Dry evergreen montane forests experience long dry seasons (4-8 months) and the rainy period is somewhat unreliable. During the dry season, not only moisture stress but also temperature increases, daytime humidity drops and water courses either dry up or greatly diminish inflow (Demel Teketay, 1996).
Dry evergreen montane forest is a very complex vegetation type occurring within an altitudinal range of 1,500-2,700 m with average annual temperature and rainfall of 14-25°C and 700-1,100 mm, respectively (Friis, 1992). It is inhabited by majority of the Ethiopian population and represents a zone of sedentary, cereal-based mixed agriculture for centuries. As a result, the forests have diminished and are replaced by bushlands in most areas. Soils have become shallow as a result of soil erosion that has been taking place for centuries (Zerihun Woldu, 1999).

Distribution

The main mountain systems of tropical Africa are the Cameroon highlands, the mountains of Kenya, the Kivu ridge and the Ethiopian highlands. In Ethiopia and Kenya, dry mountain vegetation types are extensive: evergreen or semi evergreen shrubland and thicket (with Acacia, Carissa) at medium elevation and Juniperus procera forest at montane level in Ethiopia (FAO, 2001). Dry evergreen forests have also been reported elsewhere in the tropics: Antigua, Bahamas, British Guiana, Jamaica, Trinidad and Tobago, Tanzania, Zambia, Thailand, Sri Lanka and India. There are no unified features for this rare and unique forest type and it has been chosen based on local climatic, biotic and edaphic factors which influence the forest’s physiognomy, stand structure, species composition, and dynamics (Parthasarathy et al., 2008).

The Ethiopian highlands contribute more than 50% of the land area with Afromontane vegetation, of which dry montane forests form the largest part (Tamrat Bekele, 1993). Typical dry evergreen montane forests in Ethiopia are characterized by hard-leaved evergreen species. Originally these forests occupied a large area in the northern, central, southern and southeastern highlands but by now it is considerably depleted and restricted to some isolated highlands and mountain chains in the following locations:

Menagesha-Suba forest

Menagesha-Suba forest is located 50 km Southwest of Addis Ababa at 9°00'E and 38°35'E (Friis, 1992). The topography of the area is extremely dissected, with alternating ridges and valleys dominating the landscape. The area consists of an isolated mountain surrounded by low-lying plains. The soils are light brown to reddish brown and shallow at higher altitudes, but deeper at the lower altitudes. The altitudinal range of the site is between 2,300 m and 3,000 m a.s.l. The annual rainfall in the area is estimated to be around 1,225 mm and the mean monthly temperature ranges from 12 to 16°C (Tamrat Bekele, 1993). Prior to human disturbance, the natural forest communities...
were: Hypericum belt, Hagenia-Juniperus forest, Juniperus forest, Juniperus-Podocarpus and Podocarpus forest. In addition, the natural forest has been cleared by the local people for agricultural expansion. Establishment of monoculture tree plantations was initiated in the middle of the 20th century with some indigenous and exotic species including Cupressus lusitanica, Eucalyptus globulus, Juniperus procera, Pinus patula and Pinus radiata (Tamrat Bekele, 1993).

Chilimo forest

Chilimo forest is found in western Shewa Zone of Oromia Regional State, close to Ghinchi town, the Capital of Dendi district, which is 77 km West of Addis Ababa. This area is at the western end of a chain of hills and ridges that stretches 200 km from North of Addis Ababa westwards up to Ghedo highlands. River valleys and gorges cut through the hills. Chilimo forest is one of the few remnant dry Afromontane forests on the Central Plateau of Ethiopia. The vegetation of this forest has been subjected to human impact for many years and the rate of deforestation has been extremely high. The forest consists of canopy trees such as Juniperus procera, Podocarpus falcatus, Prunus africana, Olea europaea subsp. cuspidata, Apodytes dimidiata and Ficus spp. Historically, this entire upland area is thought to have been covered by Juniperus-Podocarpus forest, but most of the forest has been cleared for agriculture and illegal cutting by the local people. Various types of shrubland patches now dominate the landscape. Few shrub species such as Myrsine africana, Maytenus arbutifolia and Rubus apetalus are abundant indicating the disturbance of the forest (Tamrat Bekele, 1993).

The Wof-Washa forest

The Wof-Washa forest is situated on the slopes of the eastern escarpment of the northwest highlands. This forest is located between 39°45′ E and 9°35′ N and covers an area of 3,600 ha. The topography is highly dissected and the altitude ranges from 2,100 to 3,600 m a.s.l. The forest area is characterized by two rainy seasons, the short rainy season from March to May and the long rainy season from July to September. Accordingly, the mean annual temperature and rainfall are 13°C and 901.3 mm, respectively. The Wof-Washa forest is located in a remote area far from roads and towns which perhaps contributed to its conservation (Tamrat Bekele, 1993; EWNHS, 1996).
Hugumburda and Grat-Kahsu forests are two contiguous forests situated between the towns of Mai Chew and Alamata, southern Zone of Tigray.

Regional State. The whole Alamata mountain area comprises volcanic rock. There is a distinctive flora associated with this rock that includes the rare endemic Delsperma abyssinica (a succulent mesembryanthemum) and the shrub Cadia purpurea. The forest block starts at the foot of the escarpment to the west of the Raya plain and continues up over very broken terrain onto the Alamata mountains, up to 2,600 m a.s.l. The forest is dry evergreen/coniferous with Juniperus procera, Olea europaea subsp. cuspidata and some Podocarpus falcatus in the higher sections. Lower down, Millettia ferruginea, Croton macrostachyus, Celtis africana, Ekebergia capensis, Prunus africana, Cordia africana and Ficus spp. are more common. Hugumburda and Grat-Kahsu forests represent the only significant expanse of dry coniferous forests in the Tigray region (EWNHS, 1996).

Yegof forest

Yegof forest is found in South Welo Zone in Amhara Regional State, on a steep mountain ridge overlooking Kombolcha town, 395 km North of Addis Ababa. It is composed of natural highland forest and plantations of fast-growing exotic trees. The natural forest, which once covered Mt Yegof, comprised dry evergreen, and mixed conifer and broadleaved trees. It is dominated by Juniperus procera. Other characteristic tree species are Olea europaea subsp. cuspidata, Erica arborea and Hypericum revolutum, with H. quartinianum at higher altitudes. Lower down are various Acacia spp., Bersama abyssinica, Croton macrostachyus, Syzygium guineense, Rhus vulgaris, Euphorbia spp., Albizia spp. and (even lower) Cordia africana (EWNHS, 1996).

Denkoro forest

Denkoro forest is found in Debre Sina district of South Wollo Zone in Amhara Regional State. It is 30 km from the district town, Mekane Selam and 215 km from Dessie. Denkoro is a remnant forest on the eastern side of Denkoro river gorge. The forested area lies between 2,400 and 3,000 m a.s.l. The lowest part is dominated by Podocarpus falcatus, with Juniperus procera, Olea europaea subsp. cuspidata and Olinia rochetiana dominating as the altitude increases. Above this, Myrsine melanophloeos (Rapanea melanophloeos) and Dombeya torrida begin to dominate along with Hagenia abyssinica. Erica arborea and Hypericum revolutum are present midway up through the forest, and gradually dominate near the top. At around 3,000 m the forest is a pure stand of Erica, gradually changing to Festuca-dominated sub-Afro-alpine grassland with some scattered giant Lobelia, Kniphofia sp. and also some scattered shrubby Erica arborea (Abate Ayalew et al., 2006).
Juniperus procera forest (Plate I) is found in the northern part of the park and also on the east around and above Goba. Around Goba there are also patches of Olea europaea subsp. cuspidata. The tree-heather Erica arborea forms a forest (up to 8 m tall) that replaces Juniperus procera at 3, 200 m a.s.l (EWNHS, 1996).

Plate I Juniperus forest in Bale Mountains National Park

The Anferara forests

The Anferara forests are found around Negele–Borana, 310 km southeast of Awassa and 470 km from Addis Ababa in Borana Zone. This area encompasses the Anferara-Wadera forest and the adjacent Bore-Anferara forest which together represent the majority of the high elevation forests in southern Ethiopia. These forests are on the highlands between two big river systems: the Genale to the east and the Awata (a major tributary of the Dawa River) on the west. The topography is rugged and broken, with many hills and ridges making it unsuitable for agriculture. However, the Kebre Mengist–Bogol Mayo (in the Genale River basin) road crosses the area. The forests are not uniform. In the north, towards Agere Selam and Kebre Mengist, the largest tree is Podocarpus falcatus, growing with a range of broadleaved species such as Croton macrostachyus, Hagenia abyssinica, Ilex mitis, Olea capensis, Schefflera abyssinica and Syzygium guineense subsp. aframontanum.
Near Negele, the vegetation is dry montane forest that used to be dominated by Juniperus procera, although nearly all of this has been cut leaving behind scrub and a few trees of other species, primarily Barbeya oleoides, Catha edulis, Olea europaea subsp. cuspidata, Pistacia aethiopica, Pittosporum viridiflorum and Schrebera alata (EWNHS, 1996).

Mankubsa-Welensu forest

Mankubsa-Welenso forest is near the Negele-Arero track between 20 and 40 km South of Negele town, the capital of Guji Zone. Negele is located at a distance of 310 km southeast of Awassa. The area is on a plateau at the western edge of the Liben plains. The forest is dominated by Juniperus procera, which forms a relatively open canopy at 25 m. Juniperus procera dominated forests are more usually found at higher altitudes than at Mankubsa–Welenso. Other species that form a lower stratum include various Acacia spp., Olea europea subsp. cuspidata, Combretum spp., Maytenus sp., and Rhus sp. A ground cover of tall grasses includes Hyparrhenia spp. and Cympopogon spp. The soils in this area are shallow sands and gravels and as a consequence are easily eroded (EWNHS, 1996).

Arero forest

The site is located around Arero town in the centre of Borana Zone in Oromia Regional State. Arero is about halfway along the track from Negele to Yabello, and 660 km from Addis Ababa. The topography of the area is undulating with some hills and gorges. Arero forest is the most southerly of the high forests of Ethiopia and is one of the few places in Borana Zone where there are well-grown trees of Juniperus procera. Podocarpus falcatus and J. procera are the largest trees and are found with broadleaved species, e.g. Prunus africana, Teclea nobilis, Croton macrostachyus, Olea capensis, Acacia spp. and Ficus spp. This forest also contains several species of small trees, characteristic of the Somali–Masai vegetation of Somalia, eastern Kenya and northern Tanzania. Examples are Fagaropsis hildebrandtii and the yellow-flowered Ochna insculpta. In Ethiopia, Ochna insculpta is only known from the Arero forest. Several tall grasses (Andropogon sp., Hyparrhenia spp. and Cympopogon spp.) grow at the periphery of the forest and the woodlands. In 1992 this area comprised 5,437 ha of closed canopy forest, 2,389 ha of medium-density forest and 2,823 ha of open forest (EWNHS, 1996).

Asebot forest

Asebot forest is one of the remaining patches of dry evergreen Afromontane forests in the country. This forest is found in West Harerge Zone of Oromia National Regional State, at about 300 km from Addis Ababa on the way to Mi’eso. The altitude of the forest ranges between 1,500 and 2,200 m a.s.l.
The rainfall regime in Asebot is bimodal with two rainfall seasons. The average rainfall of the Asebot forest ranges between 400 and 500 mm. The main rainy season is from June to August and the short rainy season is from March to May. The distribution and intensity of rainfall is tremendously variable between years and localities (Adefires Worku and Worku Zewde, 2009).

Asebot forest is mostly covered with the East African dry evergreen Afromontane vegetation formation. The characteristic species in the forest are Juniperus procera, Podocarpus falcatus, Olea europaea subsp. cuspidata, Acacia abyssinica, Croton macrostachyus, Dodonaea angustifolia, Acacia etbaica, Carissa spinarum, Terminalia sp. and others predominate the low lying parts of the mountain. The forest is surrounded by huge number of human and livestock population implying serious pressure on the forest for both wood products and grazing (Adefires Worku and Worku Zewde, 2009).

Ziqualla forest

Ziqualla forest has a high biodiversity. Around 274 vascular plant species have been recorded in the forest. Juniperus procera and Olea europaea subsp. cuspidata are the dominant tree species. Other tree species in the forest include Pittosporum viridiflorum, Buddleja polystachya, and Maytenus obscura. Clematis simensis, Jasminum abyssinicum and Rosa abyssinica are few of the climbers found in the forest. Hypericum revolutum is one of the dominant striking shrubs found at the top of the mountain (Hylander and Hylander, 1995). Ziqualla forest also consists of high diversity of birds and wild mammals (Shiferaw Alem and Rahel Muche, 2009).

The Dodola forest (Kitessa Hundera et al., 2006), Gedo forest and Sanka Meda forests are also among the dry evergreen montane forests in Ethiopia.

Plant species diversity

Dry evergreen montane forest is a multi-story forest vegetation (NBSAP, 2005). The top storey consists of a non-uniform, non-compact layer of tall trees. These trees are known as “emergents” because they project above the vegetation mass. The top story is mainly composed of old Juniperus procera trees (Tamrat Bekele, 1993). Below the layer of emergents is a mass of shorter trees of various heights. Still lower is a stratum of short trees and large shrubs, much less dense than the second stratum. Finally, there is the lowest stratum of shrubs, suffrutescents, and herbs. Epiphytes, lianas and semi-parasites are also common (Zerihun Woldu, 1999; Ensermu Kelbessa et al., 1992).
This vegetation type mostly consisted of Juniperus procera and/or Olea europaea ssp. cuspidata as the main trees with Acacia abyssinica or Acacia negrii predominating on valleys (NBSAP, 2005). Other large trees including Podocarpus falcatus, Olea capensis ssp. hochstetteri, Prunus africana, Apodytes dimidiata, etc. also occur. Smaller trees include Allophylus abyssinicus, Euphorbia abyssinica, Myrsine melanophloes, Olinia rochetiana, etc. Epiphytes including orchids, mosses and lichens (especially Usnea) are common. The shrub layer's usual constituents are Discopodium penninervium, Myrsine africana, Calpurnia aurea, Dovyalis abyssinica, etc. (Tamrat Bekele, 1993; NBSAP, 2005).

Climbers including Smilax aspera, Rubia cordifolia, Urera hypselodendron, Embelia schimperi, Jasminum abyssinicum and various species in the Cucurbitaceae, usually join the strata of vegetation. The ground is covered with grasses, and herbs including ferns and mosses. Dead plant remains form a thick soil cover. On the drier and lower part of the north and east the complexity of the vegetation is greatly reduced, and it may only be three-layered. The upper altitudinal limits also consist of simpler forests of Hagenia abyssinica with associated small trees or shrubs of Hypericum revolutum, Myrsine melanophloes, etc on deeper soils and Erica arborea scrub on the thinner soils of the slopes. Stretches of bamboo forest, Arundinaria alpina, also occur in places, its occurrence and number of individuals increasing towards the west (Ensermu Kelbessa et al., 1992; Zerihun Woldu, 1999).

This vegetation type also consisted of grassland rich in species including many legumes. Grasslands have come into existence or expanded owing to human interference and replaced most of the forest. This is especially true on the less well-drained flat areas, and invariably so on Vertisols. The grasses include various species of Hyparrhenia, Andropogon, Chloris, Pennisetum, Eragrotis, Panicum, Sporobolus, and many other genera. Other herbs including geophytes also occur in this forest type. Overgrazing, which is prevalent in most areas, tends to shift the grass flora from the more palatable grasses, e.g. Chloris gayana and Pennisetum clandistinum to less palatable highly silicified grasses, e.g. Pennisetum schimperi and Pennisetum glabrum. Legumes such as Trifolium, Eriosema and Crotalaria are also common in this vegetation type. These include a large number of endemics (Ensermu Kelbessa et al., 1992).

Wildlife species diversity

Wildlife species diversity and distribution in the dry evergreen montane forest is not that much and low due to human interferences (IBC, 2009). However, this type of vegetation is an ideal environment for elephants, buffaloes and lions.
Today, the following wildlife species such as leopard, Menelik's bushbuck, warthog, Bohor reedbuck, olive baboon, Grey duiker, and hyena still manage to thrive hiding themselves in the dense remnant dry evergreen montane forest. Various types of bird species occurring in this vegetation type include wattled ibis, blue-winged goose, black-winged plover, yellow-fronted parrot, black-winged lovebird, white-cheeked turaco, half-collared kingfisher, Abyssinian long claw and black-headed siskin (Plate 2) (EWNHS, 1996).

Plate 2 Some of the wildlife of dry evergreen montane forests

Potential contributions

Despite the destruction, trees and their products will continue to be central to the households' economies, as well as to food security and health through a number of traditional practices in Ethiopia.
The dry evergreen montane forests also provide fuel wood, construction materials, farm implements, edible fruits, honey, medicinal plants, and game for hunting. For example, trees such as Mimusops kummel, Cordia africana and shrubs such as Rubus spp, and Rosa abyssinica provide assurance against drought and crop failure and also provide a buffer during hardship period and ‘lean seasons’. In areas where livestock is limited, the forest and tree products also play major roles as good source of protein. The products of trees such as Hagenia abyssinica, Croton macrostachyus, Prunus africana, Podocarpus falcatus, Millettia ferruginea have also been and are still being used for the prevention and treatment of parasitoids, communicable diseases and pests. This is indirectly related to the household’s income by providing good health to people and the livestock as well as crops.

As one of the major activities of the local people is livestock production, it provides grazing areas. It also provides food, shelter and breeding areas for many wild animals. The forest prevents soil erosion and regulates the watershed in the surroundings and some of the forests are important water catchments for rivers. Forests regulate water flow and thus increase overall water availability for drinking and irrigation, and protect reservoirs from siltation and sedimentation. Forests are also important for biodiversity conservation which is an important storehouse of genetic material that can be used to selectively breed plants and animals with the aim of improving agricultural yield.

The other important contribution of forests is carbon sequestration. The rapid increase in global temperature due to the accumulation of greenhouse gases (GHGs) is expected to lead to regional and global changes in climate that could have significant impacts on human and natural systems. Tropical deforestation and forest degradation accounts for a large percentage of emitted CO2 (FAO, 1998). Because forests are both sources and sinks of CO2, they can play important role in mitigating climate change. Moreover, forests are ideal places for naturalists and mountaineers, and areas of great pleasure for tourists. They are also outdoor laboratories for practical training of students and researchers.

Threats and rate of change

The original forest cover of Ethiopia is not known. However, the extent of past forest cover on the Ethiopian highlands is evident from the numerous isolated mature forest trees or small patches of forests or woodlands that make conspicuous landmarks on the plateau (Friis, 1992).
Hence, large areas with evergreen bushland or farmland mixed with bushland represent formerly forested areas (Frils, 1992).

Most of the existing forest patches in Ethiopia are in a secondary state of development (Frils and Mesfin Tadesse, 1990; Tamrat Bekele, 1993). According to Tilaye Nigussie (1997) and Kumlachew Yeshitila and Tamrat Bekele (2002), the remaining primary forests of Ethiopia are confined to less accessible areas of the country. These remnant natural forests are also continuously threatened by commercial plantations of tea and coffee. EFAP (1994) estimated the annual loss of high forest area in Ethiopia between 150,000 and 200,000 ha. McKee (2007) also indicated rate of deforestation to be 146,000 ha/year. According to Wikipedia (2010), Ethiopia has lost 14% of its forest cover or around 2.1 million ha from 1990-2005. Among the different vegetation types in Ethiopia, dry evergreen Afromontane forests are severely deforested in all parts of the country (EFAP, 1994).

Various estimates on the current forest cover of Ethiopia were reported. Accordingly, the forest cover is declining and estimated to be less than 4% compared, for example, with an average of 20% for sub-Saharan Africa (Earth Trends, 2007; WBISPP, 2004). Reusing (1998, 2000) using LANDSTAT/MSS showed the extent of forest/vegetation cover of Ethiopia based on density classes, i.e., closed high forest, slightly disturbed high forest and heavily disturbed high forest. According to him, the forest cover of Ethiopia (including all the three types) was reduced to 1.41% in 1996-1997.

Because the dry evergreen montane forests are generally inhabited by majority of the Ethiopian population and represent a zone of sedentary cereal-based mixed agriculture, the forest is under severe pressure of destruction mainly because of anthropogenic impacts such as consistently increasing human habitation surrounding the forest area, poverty and illiteracy among large sections of the population, over-exploitation, site degradation and land conversion. For example, the scarcity of Juniperus procera, one of the valuable timber tree species in Ethiopia, is indicative of a strong selective logging in dry evergreen montane forests. There is also a severe and increasing fuel wood scarcity in the country, which puts extra pressure on the remaining natural forest.

Another threat to dry evergreen montane forest is the conversion of high forest sites to commercial plantations which causes ecological impacts and loss of biodiversity. Because of this forest degradation, some tree species are becoming endangered. For example, the Ministry of Agriculture has recorded the following four species i.e., Hagenia abyssinica, Podocarpus falcatus, Cordia africana and Juniperus procera as highly threatened tree species (MoA, 1994).
Causes of forest degradation

In Ethiopia, rural communities primarily depend on common property resources for irrigation water, construction material, fuel wood and grazing land. Population pressure, market and government failures, and the absence or ineffectiveness of use regulations of common property resources have also resulted in severe degradation of these resources. Hence, the causes of forest degradation in Ethiopia have economic, social, ecological, policy and institutional dimensions and could be categorized under natural, anthropogenic as well as social and policy-related factors.

Natural factors

Natural factors are further subdivided into physical environmental factors which include topography, erosion by wind and water, soil fertility decline, low organic matter content and associated physical problems such as salinity, alkalinity, etc; climatic factors such as insufficient and variable rainfall, unpredictable variation in rainfall patterns within and between seasons, occurrence of intermittent but serious drought periods that affect forests, and biological factors including diseases and pests.

Anthropogenic factors

This include deforestation which is due to clearing of forest for expanding crop land, fuel wood production, cutting of trees for construction material and for sale to generate income, and socioeconomic/infrastructural development such as resettlement, mining and road construction; overgrazing by livestock and unsustainable utilization.

The other anthropogenic factor causing deforestation is forest fire. This has been noted to be a potent threat to the meager forest resources of the country. The fire incidents that occurred between the years 1997 and 2000 are believed to have been started by individuals. The forest fires, which occurred during 1998 and 2000 in Bale, Borana, East Harerge, North Omo zones and other places destroyed an estimated 155,966 ha of forestland (Demel Teketay, 2001). In addition, the 2008 forest fire at Asebot forest alone damaged over 12,700 ha of the remnant dry evergreen Afromontane forest. Such large scale loss of forests affects not only the timber and non-timber forest products, but also all forms of wildlife therein and deprives us of the much needed ecosystem services. This would also have a serious impact on the seeds stored in the soil.
Socioeconomic and policy related factors

These contribute directly or indirectly to deforestation. These factors include poverty, population growth and poor economic performance, inadequate or absence of land use classification, land use and forest policies and legislations, absence of land and tree tenure/ownership right and inadequate institutional arrangement/set up for forestry sector.

Conservation status

Forests have virtually disappeared in northern Ethiopia exposing bare rocks, and springs and streams are drying up during the dry season. The southern and eastern parts of the country are following the same route. Many of the forests have been eliminated by human activities. As it is obviously known, the conservation status of many forests is in bad condition and not much is known about each forest. It is also known that many forests are disappearing at an alarming rate.

At present, there are no significant measures to conserve the dry evergreen montane forests. However, some community based dryland forest and woodland conservation efforts have been observed in the northern parts of Ethiopia (Gonder, Tigray and Wello). Beside this communal conservation effort, the Menagesha-Suba State Forest, which is one of the few remaining dry evergreen montane forests in central Ethiopia, has received long years of attention and protection (Tamrat Bekele, 1993).

Participatory forest management program has also been started to save the alarmingly fading dry and some other dry evergreen forests such as Chilimo, Adaba-Dodoia and Abelo forests. In Chilimo forest, for example, there has been a 150% increase in regeneration density (Tsegaye Tadesse, 2008) due to participation of the local communities in conservation of the forest.

Strategies for forest recovery

The sustainability of forest resource management depends on the balance between private and public interests and the use and benefits these resources provide for both present and future generations. To overcome deforestation and land degradation of the Ethiopian highlands and provide people with food, fuel wood and fodder on sustainable basis and to ensure healthy ecosystems, the following natural resource management strategies are proposed:
• Implementation of agroforestry and social forestry in the rural areas where subsistence farming is practised;
• Expansion of plantation forestry both industrial and non-industrial on currently uncultivated and sloping lands;
• Conservation of the remaining natural forests to conserve species and biodiversity; and
• To revise social, economic and investment policies of the country.

If properly practised and managed, these activities will help achieve sustainable production and environmental protection of the Ethiopian Highlands.

Agroforestry and social forestry

Agroforestry is an age-old practice whereby farmers maintain trees in their croplands. Such woody perennials are retained for their multiple uses and benefits, such as their nitrogen-fixing properties and soil improvement capacity, and the provision of fodder, fuel wood, and fruits.

Forest plantations

Establishment of forest plantations to provide timber and construction materials, pulp and paper for industry and public use, and fuel wood for urban dwellers is essential for future economic development of Ethiopia. Plantations can be established as pure and/or mixed stands with appropriate silvicultural techniques. This can be achieved through private sector involvement by establishing industrial plantations and non-industrial private forests. Encouraging the private sector to be involved in developing industrial forest plantations can potentially help increase self-sufficiency in wood production and contribute to the national economy. Furthermore, encouraging farmers and small land owners to be involved in tree growing scheme will enable them to generate income for the households in addition to reducing their dependence on natural forests.

About 0.5 million ha of plantation forests have been planted by the government, communities and individual farmers for industrial wood, fuel wood and production of poles. Eucalyptus spp. and Cupressus lusitanica are the main species used for industrial plantations, followed by Juniperus procera, Pinus and other species. However, the achievement in afforestation is not significant compared with the rate of deforestation.
Natural forest protection and conservation

Forest protection can be defined as safeguarding natural areas by law or custom where species and ecosystems are conserved for current and future generations. Since the best way to maintain species is to maintain their habitats, protected areas are essential means for sustaining diversity. Protected areas also help in stabilizing the local climate, protecting watersheds, and preventing erosion.

Protected areas constitute the most widespread mechanism used to conserve the remaining natural forests of Ethiopia. Conservation must be a part of a broader process of managing the whole landscape. Thus, protected areas will contribute to the conservation of the remaining natural forests in Ethiopia, if they are able to meet the legitimate developmental aspirations of the people that live in and around them (Sayer et al., 1992). Protection and conservation of the remaining natural forests is critical to protect species and biodiversity because future existence of the woody species of dry Afromontane forests in Ethiopia depend on the conservation and sustainable utilization of the few remnant natural forests (Feyera Senbeta and Demel Teketay, 2002). Hence, to ensure the sustainability of the forest resource, the ecosystem approach to the management of these resources is the only viable strategy. This approach also ensures the integrated management of land, water, and living resources by promoting conservation and sustainable use in an equitable way.

Social, economic and policy issues

Deforestation and land degradation should be seen as the most important issues threatening the survival of Ethiopia. Floods, drought, desertification, drying up of streams, and soil erosion are connected in one way or another to the process of forest exploitation and destruction. Although various potential strategies for tree planting and natural resource conservation on the Ethiopian highlands are proposed, their successful implementation will be limited unless the following social, economic and policy issues are addressed properly.

a. Participation of the rural and urban people: This can be done through a participatory process where farmers and local people are involved in planning, designing and implementation of the management plan. This exchange of information and partnership will help build confidence and reassure all that the programmes are relevant to their needs and ensure they have a sense of responsibility towards the project.
b. Economic incentives: Wood should not be considered a free good, rather, it should be considered one of the commodities that require land, labor and capital to produce. Thus, it should be priced based on capital and resource invested, and demand and supply in the market place. This will be a great incentive for establishing forest plantations and small private forests in the country. Incentives may involve supplying seeds and seedlings either freely or at a nominal price. Ensuring an adequate supply of hand tools for planting and temporary food aid can encourage farmers to participate in tree planting and adoption of agroforestry technology.

c. Land and tree tenure: Successful long-term agroforestry and tree planting strategies require land tenure systems that guarantee continued ownership of land. The incentive for investing in soil fertility improvement for the future is low unless the benefits accrue to the tree planter (Sayer et al., 1992). This holds true in Ethiopia today where land is still under the communal control of the government. Unless land is redistributed to individual farmers and they are guaranteed continuous ownership, success in the adoption of agroforestry and tree planting is unlikely. Therefore, the land and tree tenure policy of the country should be changed to reward the farmers who invest in agroforestry and forest plantations, which require long gestation periods.

d. Education and research: Adequate forestry and natural resource education, research, and extension service is needed to meet the demand for and challenges of managing our natural resources on a sustainable basis. Strengthening the education and research institutions in the country to train qualified forestry and natural resource professionals with appropriate knowledge of forestry and agriculture in Ethiopia is required. Research in agroforestry in Ethiopia in general should emphasize on the development of appropriate technologies suitable for increasing agricultural productivity and reclamation of degraded highlands. Also, research in plantation forestry should focus on production of fiber and other benefits while maintaining the ecosystems. Conservation of the natural forests should be given adequate attention and research in these forests should focus towards improving natural regeneration of the various species and conservation of biodiversity.

Investment policy and legislations and marketing of forest products

The federal government's law on investment incentives provides tax incentives like tax exemption on income from activities of enterprises that export most of their products and also the exemption from customs duty on items imported for the purpose of running and expanding such enterprises. If such incentives are made well
known to private investors, they will be encouraged to participate in forest conservation and development programmes so that they may ensure a sustainable flow of raw material for their enterprises and thereby indirectly contribute to the increment of forest cover.

Opportunities for forest rehabilitation in Ethiopia

Forest development, conservation and utilization policy and strategy

Recently, in April 2007 the Council of Ministers adopted a forest policy for the first time in history. The government has given due attention to forest development and conservation considering its significance to the national economy, food security and sustainable development of the nation. In its preamble, the policy stated that degradation of resources such as soil and vegetation cover caused desertification, increased recurrence of severe drought and also migration of rural population to urban areas.

The overall objective of the policy is thus to conserve and develop forest resources properly so that there could be sustainable supply of forest products to the society (hence satisfying the demand) and contribute to the development of the national economy. The enactment of this law can be used as a ground in saving the alarmingly fading dry evergreen montane forests in the country.

International conventions

Ethiopia is signatory to most of the key international environmental conventions such as the Convention on Biological Diversity (CBD), the UN Convention to Combat Desertification (UNCCD), the UN Framework Convention on Climate Change (UNFCCC) and the Convention on International Trade in Endangered Species (CITES). Acknowledging such important conventions and considering/owning them as the country's laws and policies are indicative of the government's commitment to the issue of environment. These conventions would help in assisting forest cover increase through financial mechanisms.

Rich soil seed bank and seedling bank

Dry Afromontane forests are characterized by possessing large population of buried soil seed banks and persistent seedling bank that will contribute to the efforts of rehabilitating the damaged sites (Demel Teketay, 1996).
Tree planting

With the intention of mitigating the effects of deforestation and climate change such as drought and soil erosion, Ethiopia has embarked upon an extensive aorestation programme, especially since the turn of its new millennium through a campaign “Two Trees for 2000”. Since then, it has been transplanting various tree seedlings across its territory to restore its forest-depleted areas in particular by actively involving different segments of the society. This is again an important opportunity in the efforts to rehabilitate the degraded forest sites in different parts of the country.

Remaining challenges

- Tree and land tenure/rights remain an issue of concern. Agroforestry and forest plantations, which require long gestation periods, need secured right over land.
- As most woodlots are planted with eucalyptus and other exotic tree species, environmental challenges related to these trees are significant. For example, a criticism associated with eucalyptus trees is the depletion of soil nutrients. In contrast to commonly used agroforestry species, eucalyptus does not fix nitrogen, an essential element for soil health and sustainability. This has negative effects on agricultural practices on and near eucalypt woodlands.
- Frequent restructuring of both federal and regional environmental and forestry institutions is a typical exercise in Ethiopia. This delays planned activities from being performed.
- Seedling survival rate is low (10%) (McKee, 2007) because of inadequate care and premature cutting by nearby residents.

Recommendations

Given the current scenarios at hand, the most affected groups due to depletion of forest resources are those local communities that strongly depend on resources surrounding them. Therefore, efforts to conserve and sustainably utilize these resources should allow the participation of the local (indigenous) people in such a way that ownership and use right issues are properly addressed. Denial of access to these resources results in loss of sense of ownership and responsibility which may lead to massive exploitation of natural forest resources by local communities. Therefore, the following long-term conservation strategies should be implemented.
Executive Summary

- Promote awareness of biodiversity and bioresource values and cultural traditions associated with the sacred groves to indigenous people living around the dry evergreen montane forest sites and people who are also dependent on the forests and their resources so that they will be benefited from conserving the sites that still remain relatively undisturbed.

- Restore disturbed forest sites with characteristic dry evergreen montane forest species, involving the local communities in restoration programmes, in nurturing the planted saplings, by providing legal status to the forests and developing forest management systems involving the local community.

- It is important to note that the factors that drive the local people or settlers to burn the forests should be identified and appropriate mitigation measures be taken to halt the problem.

- The bioresource potential, especially the medicinal and other economic importance of dry evergreen montane forest species, deserves detailed documentation in the additional unstudied sites. Hence, further researches for bioresource augmentation and full utilization such as developing propagation and nursery techniques for large-scale multiplication of multi-beneficial species and species of high medicinal importance and phyto-chemical screening and bioprospecting of important species should be carried out.

- Establishing appropriate institutional arrangement/framework with adequate budget and trained manpower is important to develop and implement sustainable forest resource management programmes at all levels.

- Encouraging greater involvement of the civil society in forestry activities at both the local and national level and acknowledging/rewarding those individuals/institutions with better performance in forest rehabilitation.

- Recognizing forest management in the provision of different forest goods and services such as provision of food and feed, improvement of the organic content of the soil, nutrient recycling, soil and water conservation, biodiversity conservation and mitigating climate change, to support sustainable agricultural production for food self-sufficiency, livelihood improvement and the overall economic growth of the country.

- Biomass energy at the national level provides more than 96.9% of the total energy consumption of which 78% is from woody biomass (WBISPP, 2004). Therefore, promoting alternative energy sources at affordable price to the majority of the population could reduce the dependence on wood fuel.
References


FOREST TYPES IN ETHIOPIA


MOIST MONTANE FORESTS OF ETHIOPIA

Feyera Senbeta

Introduction

To provide a working perspective for a discussion about moist montane forests of Ethiopia, it is first necessary to define what a montane forest is. A montane forest is a forest that grows in mountain areas. It generally occurs on more humid mountains, and most frequently in the tropics, where the most widespread mountain areas appear (Stadtmüller, 1987). Montane forests represent a rare and fragile ecosystem that is under threat in many parts of the world (Stadtmüller, 1987; Mercader, 2002; Bubb et al., 2004). Altitude and slope and the environmental gradients they create are key components that influence the formation of montane forest vegetation.

There are vast mountain systems in Africa, named as Afromontane Region, that also maintain forest vegetation. The main Afromontane systems of tropical Africa are the Ethiopian highlands, the mountains of Kenya and Tanzania, the Kivu ridge and Cameroon highlands. The vegetation of these mountains is extremely diverse and varies with climate.

Montane forests play an important role in maintaining the stability of mountain systems and supporting the people who live there (Plate 1). More than half of humanity relies on the fresh water that accumulates in mountains for drinking, domestic use, irrigation, hydropower, industry and transportation (Butt and Price, 1999). Montane forests help to capture and store essential atmospheric moisture to regulate river flow and reduce erosion and sedimentation downstream. They are important sources of timber and other wood and non-wood products, and are especially important as sources of fuel for the local population and for those in nearby foothills and plains. Additionally, they are very important as repositories of biodiversity (Uhlig, 1988; Tadesse Woldemariam, 2003; Feyera Senbeta, 2006); and as a result are increasingly important for tourism and recreation as well as hunting and fishing.
Because montane forests are usually isolated from similar ecosystems by steep terrain and intervening lowlands with contrasting climates, they are frequently sites of high species endemism (Butt and Price, 1999).

Plate 1 Montane forest and local people

Despite these values, montane forests are often highly threatened by the activities of growing human population around them. Some of the most densely populated areas of the world are mountainous regions, where the demand for land to grow crops, collect fuel wood for cooking and heating, and for construction materials combine to exert high pressure on the remaining forests (Butt and Price, 1999). More importantly, the kind of local distribution tends to make species more vulnerable to extinction; and this combined with increasing pressures on mountain ecosystems has led to the inclusion of many montane forest species on the lists of the world’s most critically endangered species. FAO (1993) estimated the annual loss of forest from upland regions in the tropics to be 1.1-30% higher than elsewhere in the tropics.

Montane forests of Ethiopia differ significantly from other montane forests of the world in their structure, composition and physiognomy (Friis, 1992; Bussmann, 2002). It is commonly categorized into moist and dry montane forests based on precipitation regimes, the first of which is the focus of this paper. Different authors have named this forest vegetation differently: (Afro) montane rainforest (Friis, 1992), moist montane forest or moist montane evergreen forest (Friis, 1986; Anteneh Shimelis et al., 1996; Zerihun Woldu, 1999). Hereafter “moist montane forest” is adopted throughout this paper. The form and appearance of moist montane forests vary greatly according to how exposed they are to the prevailing winds, altitude and local soil types.
On lower mountain slopes (< 1,500 m), the forest is a type of transitional forest that possesses the characteristics of both lowland and moist montane forests. At the upper part of the mountains (around 2,500 and above), bamboo (Arundinaria alpina) forest occurs often mixed with broad-leaved species.

Ethiopian moist montane forests occur within a wide range of annual and seasonal rainfall patterns, from 700-2,500 mm/year; with a mean annual temperature range of 15 to 20°C. They are found wherever the rainfall intensity and frequency are abundant within a mountain slope. They typically form a belt of vegetation over an altitudinal range between (1,000-)1,200 and 2,600 m in the southwest of the NW and SE highlands of Ethiopia. The tree canopies are characteristic made up of a mixture of broad-leaved species like Pouteria adolfi-friederici, P. altissima and Olea welwitschii, and Podocarpus falcatus. Noteworthy is that P. falcatus is predominant in the southeast and gradually becomes rare towards the southwest and west while Pouteria altissima (in the lower altitude) and P. adolfi-friederici (in the higher) become more prominent. Some of the canopy characteristic species include Ekebergia capensis, Ilex mitis, Millettia ferruginea, Olea welwitschii, Polyscias fulva, Prunus africana, and Sapium ellipticum.

A segment of this moist montane forest has long been recognized as the centre of origin and diversity of wild Coffea arabica (Strenge, 1956; Meyer, 1965; Tadesse Woldemariam, 2003; Kassahun Tesfaye, 2006). Currently, wild populations of Coffea arabica occur in many moist montane forest fragments, which are geographically separated and isolated from each other due to settlements and farmland. Like other forests, these forest fragments are under continuous threat due to the expansion of agriculture and commercial plantations (e.g. tea, coffee) and also to modifications of the forest coffee due to the management of wild coffee (Demel Teketay, 1999; Tadesse Woldemariam et al., 2002; Feyera Senbeta and Denich, 2006; Feyera Senbeta et al., 2007a, b, c). Whatever the causes of deforestation might be, the bottom line is that conservation efforts are mandatory in order to maintain the remaining moist montane forests. A diverse range of social, economic and ecological information about the forest is necessary to design suitable conservation and sustainable use approaches.

Increasingly, it is recognized that montane forests can be sustainably managed through approaches that recognize the linkages between ecosystem and societal processes.
The rights and stewardship responsibilities of local communities, supported and arbitrated by national or regional institutions are essential starting points. However, much work is needed to develop and implement such methods. The many interactions between forests and agricultural land use in mountain regions must be recognized. Issues of land tenure, training, natural regeneration techniques and, sometimes, the provision of suitable species are central to sustainable land use which involves not only forests but the trees outside the forests, which are often valuable for producing fodder and fruit and for slope stabilization.

The present paper gives an overview of the status, potential contributions and threats of moist montane forests in Ethiopia and of the natural and man-made restitution efforts. The analysis is based on data drawn from different sources. Recommendations for conservation of the last remaining moist montane forests in Ethiopia are proposed.

Forest classification

Forest is a complex ecosystem predominantly consisting of trees that shield earth and support innumerable life forms. Not all forests are alike. In any geographical region, environmental factors such as climate, soil types, topography and elevation determine the types of forests (Stadtmüller, 1987; Friis, 1992; Bubb et al., 2004). In other words, local environmental factors determine which individual species can grow in a place and which different species can grow together. We recognize and classify forest types based on the distinct associations of different forest communities within the broader region due to the variations in environmental factors. Hence, forests can be classified in diverse ways and to different degrees of specificity such as coniferous forests, temperate forests, tropical forests, montane forests, etc. In specific terms, whether the forests are predominantly composed of broad-leaved trees, coniferous (needle-leaved) trees, or mixed. Apparently, scientists characterize forest types using geographical position (e.g., southwestern forest), climate (e.g., tropical), dominant vegetation (e.g., Olea forest), gross appearance (physiognomy), species composition (combination of species living together) and others.

In Ethiopia, many scholars have attempted to categorize the vegetation of forests (Logan, 1946; Chaffey, 1979; Friis, 1986; Friis and Mesfin Tadesse, 1990; Friis, 1992). Most classifications are based on climate, physiognomy and species composition. The classification by Friis (1992) employed a combination of floristic and physiognomic forest classification and recognized seven forest types.
These include: lowland dry peripheral semi-deciduous Guineo-Congolian forest; transitional rainforest; Afrotropical rainforest; undifferentiated Afrotropical forest; dry single-dominant Afrotropical forest of the Ethiopian highlands; dry single-dominant Afrotropical forest of the escarpments; and riverine forest. A detailed account of each forest can be seen in Friis (1992). Out of these aforementioned forest types, moist montane forest which also includes transitional rainforest is the subject of the present review paper.

Location and distribution of the forest

The moist montane forest ecosystem of Ethiopia is found mostly in the southwestern plateau (Figure 1).

The vegetation zonation of Ethiopia and the relative position of moist montane forest are shown in Figure 2. The figure shows eight vegetation types which include moist montane forest, which is located within altitudinal range between (1,200-1,500 - 2,500 m a.s.l. Moist montane forests receive the highest mean annual rainfall in the country, reaching over 2,500 mm in some places. Some good examples of the moist montane forests of Ethiopia are Tiro-Boter-Bacho, Belete-Gera, Yayu, Sigmo-Gatira, Harenna-Kokosa in Oromia Regional State (in Jimma, Illubabor and Bale Zones, respectively) and the Masha-Anderacha, Bonga, Sheko forests in Southern Nations, Nationalities and Peoples Regional State (in Shaka, Kaffa and Bench-Maji Zones, respectively).
These forests are recognized as high forests with closed continuous canopy cover. Most of the forests in the southwestern plateau which seem to be intact from above canopy are highly influenced due to coffee management. The trees have been selectively felled for timber, construction, expansion of agriculture as well as coffee and tea plantations.

**Vegetation zonation**

<table>
<thead>
<tr>
<th>Acid soils</th>
<th>Alkaline soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500 - 2500 mm Rainfall</td>
<td>0 - 500 mm</td>
</tr>
<tr>
<td>500 - 2000 mm</td>
<td>1000 - 400 m Altitude</td>
</tr>
<tr>
<td>0 - 500 mm</td>
<td>&lt; 400 m</td>
</tr>
</tbody>
</table>

**Figure 2 Vegetation zonation and the relative position of moist montane forest**

**Geology and soils**

Studies of the geology of Ethiopia have been made by Mohr (1965, 1971) and Kazmin (1972). The great mass of the moist montane forest belt of western Ethiopia is largely made up of volcanic rock, which is composed of mainly alkali olivine basalt and tuffs; whereas the southeastern moist montane forests are formed from lava outpourings in the Miocene and Oligocene geological periods (Mohr, 1965). This trapped lava covered all previous rock formations and was formed prior to the formation of the Rift Valley, probably about 40-25 million years ago (Mohr, 1965; Mohr, 1971; Umer and Bonnefille, 1998).

The soils occurring beneath moist montane forests are generally of medium texture, brown or reddish brown, deep and freely draining (Feyera Senbeta, 2006).
In most cases, these soils are noted as dark reddish-brown, silt-clay rich in basic exchangeable cations. The clay content may increase and the colour becomes redder with depth. A study by Feyera Senbeta (2006) listed the major soil types in some moist montane forests of southwestern Ethiopia. These are Cambisols, Acrisols, Regosols and Nitosols.

Structure and composition

Forest structure

It has been suggested that most moist montane forests of Ethiopia have similar structure despite floristic differences (Feyera Senbeta, 2006). The structural features which are usually compared are the density, basal area, height, diameter and stratification of the trees. The following account is based on a study of the sample plots of 400 m² in the different moist montane forests.

Density and basal area

The densities of five moist montane forests (i.e., Bonga, Sheko, Yayu, Harenna and Maji) are shown in Table 1, which are expressed as density per plot and hectares. The density of woody plants ranged from 9,309-69,130 individuals/ha in the five moist montane forests. Moist montane forests have a high density of individuals which, however, differs between sites. These differences may be explained by the complex interactions of the different historic factors. For example, the high plant densities in the Yayu moist montane forest might be attributed to the successional stage of the forest. Many natural disturbances, such as fire, may affect the succession processes of a forest. The Yayu forest probably has been subjected to some disturbance in the past. During early successional development, many pioneer species may establish and grow together in high density until they reach the climax stage where many individuals are eliminated due to competition (Ewel, 1983). The low density in the Harenna forest is, thus, related to heavy human-related disturbance and the forest is at its early successional development.
**Table 1 Density and basal area of woody plants in some moist montane forests of Ethiopia**

<table>
<thead>
<tr>
<th>Characteristics*</th>
<th>Bonga</th>
<th>Sheko</th>
<th>Harenna</th>
<th>Maji</th>
<th>Yayu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total plots</td>
<td>28</td>
<td>37</td>
<td>24</td>
<td>10</td>
<td>48</td>
</tr>
<tr>
<td>Total density</td>
<td>21,540</td>
<td>24,296</td>
<td>8,937</td>
<td>7,273</td>
<td>132,729</td>
</tr>
<tr>
<td>Min density/plot</td>
<td>169</td>
<td>303</td>
<td>89</td>
<td>432</td>
<td>955</td>
</tr>
<tr>
<td>Max density/plot</td>
<td>1,459</td>
<td>1,756</td>
<td>1,980</td>
<td>1,209</td>
<td>7,684</td>
</tr>
<tr>
<td>Median of density/plot</td>
<td>777</td>
<td>570</td>
<td>178</td>
<td>665</td>
<td>2,642</td>
</tr>
<tr>
<td>Density/ha</td>
<td>19,232</td>
<td>18,981</td>
<td>9,309</td>
<td>18,183</td>
<td>69,130</td>
</tr>
<tr>
<td>Basal area (m²/ha)</td>
<td>47</td>
<td>54</td>
<td>49</td>
<td>53</td>
<td>46</td>
</tr>
</tbody>
</table>

*Source: Feyera Senbeta, 2006

Additionally, the total basal area per hectare and density of woody plants for some moist montane forests are also shown in Table 1; the basal area ranged from 46-54 m².

**Tree height and diameter distribution**

Various studies have shown the patterns of height and diameter distribution in the different moist montane forests of Ethiopia (Tadesse Woldemariam, 2003; Feyera Senbeta, 2006; Schmitt, 2006). For example, the patterns of height (> 0.5 m) distribution of the woody species in some moist montane forests (e.g., Bonga, Sheko, Yayu, Harenna and Maji) are shown in Figure 3. It revealed a high proportion of individuals in the lowest height class and few individuals in the higher height classes. For example in Maji, about 90% of individuals recorded are represented in the height class of 0.5 to 5 m and only <1% reached a height of more than 30 m. It is only in the Harenna forest that the higher height class, i.e., > 30 m, is relatively well represented (6%).
Figure 3 Height class frequency distribution of woody plants in the studied moist montane forests of Ethiopia. Class 1 = 0.5-5 m; 2 = 5-10 m; 3 = 10-15 m; 4 = 15-20 m; 5 = 20-25 m; 6 = 25-30 m; 7 = > 30 m (Abbreviation: BO-Bonga; BK-Sheko; MA-Maji; HA-Harenna; and YA-Yayu Forest)

Similarly, diameter distributions (> 2.5 cm) from the same moist montane forests are shown in Figure 4. A considerable number of individuals were found in the lower diameter classes. For example, 69% of the individuals in the Bonga forest were found in the dbh class between 2 and 5 cm and 45% in Harenna. The number of individuals within the largest diameter class > 47 cm ranged between 1% (Bonga) to 4% (Harenna). The largest diameter was recorded in the Harenna forest, i.e., 200 cm for Podocarpus falcatus (Harenna), followed by 187 cm for Schefflera abyssinica (Bonga), 150 cm for Pouteria altissima (Berhane-Kontir) and 143 cm for Manilkara butugi (Maji).
Figure 4 Diameter class frequency distribution of all woody plants within the studied rainforests of Ethiopia. Diameter at breast height (dbh) Class: 1 = 2-5 cm; 2 = 5-11 cm; 3 = 11-23 cm; 4 = 23-47 cm and 5 = > 47 cm

Tree height and diameter distribution

A study by Feyera Senbeta (2006) has shown that most moist montane forests have 2-3 strata of tree layers, i.e., emergent/upper stratum (> 30 m tall), middle tree stratum (15-30 m tall) and small trees and shrub layer (2-15 m tall). A few trees of the upper stratum, which are not in lateral contact, are raised well above the middle tree stratum and have a large number of branches. The middle tree stratum is often narrow and may be either discontinuous or continuous. The lower tree stratum usually forms a dense canopy. The herbaceous layer is usually sparse and consists of forest grasses and ferns. Lianas and strangling epiphytes are abundant. Nevertheless, in different forest areas the upper canopy layer was occupied by different tree species, which probably explains the difference in climatic, edaphic and/or historical factors in each forest. Two-layer stratification is common in species-poor forests in Ecuador (Grubb et al., 1963). In addition to physical environments, human factors can modify the vertical stratification of the forest. Logging has occurred in most forests of Ethiopia in the past. In particular, there is a long history of human settlements in the highlands of Ethiopia. These human activities must have contributed to the reduction of the upper canopy trees, as most of these species are used for timber, e.g., Pouteria adolfi-friederici and Olea welwitschii.
As an example, the profile diagram of the Bonga forest reflects the upper canopy of Olea welwitschii stand at 1,970 m a.s.l. (Figure 5). Except for a few 30-40 m emergent trees (mostly Olea welwitschii, sometimes Pouteria adolfi-friederici), the height of the canopy varies between 15 and 20 m. The characteristic species of the middle stratum include Elaeodendron buchananii, Polyscias fulva, Millettia ferruginea and Syzygium guineense. The understory layer consists of small trees and shrubs with dense crowns between 2 and 15 m, with mainly Coffea arabica, Dracaena afromontana, Chionanthus mildbraedii, Psychotria orophila and Galiniera saxifraga. The herbaceous layer is patchy and the patches are variable in size and density.

Figure 5 Profile diagram of an Olea welwitschii stand (61 m x 7.6 m) in the Bonga forest at 1,970 m a.s.l. Ca = Coffea arabica; Eb = Elaeodendron buchananii; Ow = Olea welwitschii; Da = Dracaena afromontana; Pr = Phoenix reclinata; Mf = Millettia ferruginea; Pf = Polyscias fulva; AF = Podocarpus falcatus; Sg = Syzygium guineense

A floristic study of moist montane forests was made by several researchers (e.g., Chaffey, 1979; Friis et al., 1982; Friis, 1986; Uhlig, 1988; Friis, 1992; Lisaneework Nigatu and Mesfin Tadesse, 1989; Kumilachew Yeshitela, 1997; Zerihun Woldu, 1999; Tadesse Woldemariam, 2003; Feyera Senbeta et al., 2005; Feyera Senbeta, 2006; Schmitt, 2006; Ensermu Kelbessa and Teshome Soromessa, 2008; Ermias Lulekal et al., 2008; Feyera Senbeta et al., 2008;
Feyera Senbeta et al., 2009a,b). However, most of these studies focused on vascular plants, mainly on trees, shrubs, climbers and herbs including ferns. A study by Feyera Senbeta (2006) was most comprehensive and considered different moist montane forest fragments and recorded over 650 vascular plant species. From these fragmented studies over 700 vascular plants were recorded in the moist montane forest of Ethiopia, which is about 12% of the total vascular plant flora of the country. However, non-vascular species are scarcely studied in these forests.

As an example, the floristic analyses of the five moist montane forests (i.e., Bonga, Sheko, Yayu, Harenna and Maji) altogether yielded 651 species (Table 2). This total includes 16 pteridophyte families, two gymnosperm families, 19 monocotyledon and 83 dicotyledon families. Of the total number of species, 50 pteridophytes, two gymnosperms and 599 angiosperms are represented in the forests.

Table 2 Number of plant families, genera and species found in the studied Afromontane rainforests of Ethiopia

<table>
<thead>
<tr>
<th></th>
<th>Bonga</th>
<th>Sheko</th>
<th>Yayu</th>
<th>Maji</th>
<th>Harenna</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of families</td>
<td>91</td>
<td>91</td>
<td>69</td>
<td>57</td>
<td>87</td>
</tr>
<tr>
<td>No. of genera</td>
<td>213</td>
<td>256</td>
<td>163</td>
<td>124</td>
<td>212</td>
</tr>
<tr>
<td>No. of species</td>
<td>285</td>
<td>374</td>
<td>217</td>
<td>146</td>
<td>289</td>
</tr>
<tr>
<td>Genera/families</td>
<td>2.34</td>
<td>2.81</td>
<td>2.36</td>
<td>2.18</td>
<td>2.44</td>
</tr>
<tr>
<td>Species/genera</td>
<td>1.34</td>
<td>1.46</td>
<td>1.33</td>
<td>1.18</td>
<td>1.36</td>
</tr>
</tbody>
</table>

Out of the total 118 families recorded, 47 (40%) occurred in all five forests, 15 (13%) in four forests, 14 (12%) in three forests, 17 (14%) in two forests and 25 (21%) in one forest only. The implication is that most moist montane forest taxa of Ethiopia are restricted in their range of distribution. Apparently to capture the diversity of organisms within the different regions, conservation areas have to be replicated across the different moist montane forests.

The characteristic species of moist montane forests are described as follows. The emergent canopy or emergent layer of moist montane forest occupies the layer above 30 m height and is usually discontinuous. Emergent canopies are characteristically made up of a mixture of Podocarpus falcatus and broad-leaved species.
Noteworthy is that Podocarpus falcatus is predominant in the southeast and gradually becomes rare towards the southwest while Pouteria adolfi-friederici becomes more prominent there. The southeast moist montane forest is floristically closely related to the southwest and west moist montane forest except for a few forest tree species not known in other parts of Ethiopia, e.g., Filicium decipiens.

Among the most frequent canopy tree species of the moist montane forest are A. schimperiana, Albizia gummifera, Apodytes dimidiata, Celtis africana, Cordia africana, Croton macrostachyus, Ekebergia capensis, Ilex mitis, Milletia ferruginea, Mimusops kummel, Olea welwitschii, Polycias fulva, Prunus africana, Sapium ellipticum, Schefflera abyssinica and Trichilia dregeana. There are additional species that are infrequent and mostly common in lower elevation often named as ‘transitional forest’, which is located between the moist montane and lowland semi-evergreen forests that include Celtis gomphophylla, C. philippensis, Morus mesozygia and Trichilia prieuriana.

The most frequent smaller tree species include Allophylus abyssinicus, Bersema abyssinica, Blighia unijugata, Bridelia micrantha, Cassipourea malosana, Chionanthus mildbraedii, Dracaena afrormontana, Ehretia cymosa, Elaeodendron buchananii, Lepidotrichilia volkensii, Maesa lanceolata, Nuxia congesta, Oxyanthus speciosus, Rothmannia urcelliformis, Schrebera alata, Strychnos mitis, Teclea nobilis and Vepris dainellii. Natural coffee is one of the characteristic species in the understory between 1,000 and 2,000 m a.s.l.

Most species usually occur as shrubs but some often form smaller trees which include Allophylus macrobotrys, Crossopteryx febrifuga, Galiniera saxifraga, Psychotria orophila, Psydrax parviflora, Rytigynia neglecta and Vangueria apiculata.

Some of the most frequent lianas include Gouania longispicata, Hippocratea africana, Hippocratea goetzei, Jasminum abyssinicum, Landolphia buchananii, Oncinotis tenuiloba, Rubus apetalus, R. steudneri, Tiliacora troupini and Toddalia asiatica. Epiphytes are very common and include Aerangis luteoalba, Arthropteris monocarpa, Asplenium aethiopicum, A. sandersonii Loxogramme abyssinica and Peperomia tetraphylla.

The lower belt of the southwestern moist montane forest which is sometimes named as transitional rainforest (Friis, 1992) is characterized by tree species such as Anthocleista schweinfurthii, Celtis gomphophylla, C. philippensis, Manilkara butugi, Morus mesozygia, and Pouteria altissima. Some of these species have common association with Guineo-Congolian forests.
Biodiversity features

Moist montane forests have very high levels of endemism and are home to many threatened species. On a global scale, the importance of moist montane forests of Ethiopia for biodiversity conservation is significantly high (EWNHS, 1996; Friis et al., 1982; Lisanework Nigatu and Mesfin Tadesse, 1989; Friis, 1992; Uhlig, 1988; Tadesse Woldemariam, 2003; Kassahun Tesfaye, 2006; Feyera Senbeta, 2006). Most moist montane forest species are often restricted in their range of distribution. Globally, a segment of moist montane forest is the only forest ecosystem with the occurrence of wild populations of Coffea arabica. The forests maintain a high number of economically useful plant species such as Piper capense, P. guineense, Dioscorea bulbifera, D. praehensilis, Aframomum corrorima and Trichilia dregeana. These forests can be gene reserves for many useful forest species beside the wild coffee populations. The montane forests of Ethiopia are part of the recently designated “Eastern Afromontane Hotspot” (CI, 2004), which is one of the globally important regions for biodiversity conservation. If an ecoregion is to qualify as a hotspot, it must contain at least 1,500 species of vascular plants (> 0.5 percent of the world’s total) as endemics and must have lost at least 70% of its original habitat (Myers, 1988; Myers, 2003).

Plant diversity. The moist montane forest ecosystem is the most diverse ecosystem in composition, structure and habitat types. This ecosystem lies on mountainous areas which allows the existence of wide ecological gradients along the altitudes. As a result, large complexes of montane forests exist forming several distinct vegetation units. The various vegetation units, therefore, support different flora and fauna that can be distinguished as forming unique associations. The structural diversity in the forest also allows both animals and plants to occupy different ecological niche. The moist montane forests are also interspersed by patches of various grasslands and wetlands which have their own unique faunistic as well as floristic associations. The high forests are not only diverse in their composition but also hold important genetic components and populations of wild coffee and several associated economic plant species.

Animal diversity. Several animal species are known to inhabit the montane forest ecosystem although intensive scientific investigations are lacking. Larger mammals living in this ecosystem include, among others, lion, leopard, black leopard, serval, black common jackal, wild dog, wild cat, bush pig, giant forest hog, warthog, colobus monkey, olive baboon, grey duiker and bushbuck.
Although complete inventory is lacking, some of the moist montane forests are recognized to be important bird areas in Ethiopia (EWNHS, 1996). For example, Bonga forest consists of more than 15 highland species of birds; Metu-Gore-Tepi forests consist of more than 16, out of which at least two are endemic; and Tiro-Boter-Becho forest is also home to more than 32 highland biome species of birds (EWNHS, 1996).

The importance of moist montane forests

Moist montane forests exhibit many values related to the uniqueness of these ecosystems, in terms of their diversity and endemism, and the functions they provide.

As sources of livelihood

Many people living in and around the moist montane forests are deriving their livelihood directly or indirectly from the forest. The major livelihood sources are: coffee, honey, spices, wild food, medicine, farm tools and fuel wood. They are also sources of timber and related products. A study by Demel Teketay et al. (2010) recorded over 61 plant species that are used as food (wild edible plants) and over 70 plant species which are highly important for various other uses. According to these authors, over 50 medicinal plants have been recorded from different fragments of moist montane forests. However, very few species have been domesticated. For example, a study by Feyera Senbeta (2006) in five moist montane forest fragments of Yayu, Sheko, Bonga and Maji (all in the southwest) and Harenna forest (southeast Ethiopia) has reported a significant number of useful plants (Plate 2).

Some of the most encountered and economically important species are: Aframomum corrorima, Capsicum frutescens, Carissa spinarum, Clematis simensis, Cordia africana, Dioscorea praeheislis, D. sagittifolia, Ensete ventricosum, Ocimum lamifolium, Ficus mucuso, F. sur, Manilkara butugi, Mimusops kummel, Passiflora edulis, Phoenix reclinata, Piper capense, P. guineense, Rhamnus prinoides, Rubus apetalus, R. rosifolius, R. steudneri, Solanum nigrum, Syzygium guineense, Trilepisium madagascariense, Trichilia dreganea and Urtica simensis. These forests are gene reserves for many useful forest species as well.
Plate 2 Two important spice species in southwest moist montane forests, *Aframomum corrorima* (middle) and *Piper capense*

As previously indicated, the fragments of moist montane forests of Ethiopia are the only natural habitat of wild Arabica coffee populations (Plate 3). These wild coffee genetic resources are important both for national and international coffee breeding programmes that aim at increasing productivity, disease resistance and tolerance, low caffeine content and tolerance to drought and the like. The Ethiopian gene pool in the wild coffee populations can contribute considerably to these aims. For example, the economic value of coffee genetic resources was estimated on the basis of assessing three breeding programmes which include resistance to coffee berry disease and coffee rust, low caffeine content and increased yields. The resulting economic value of coffee genetic resources amounts to around USD 0.5 - 1.5 billion (Hein and Gatzweiler, 2006). This demonstrates the high economic value of coffee genetic resources in Ethiopia and underlines the need for urgent action to halt the currently ongoing, rapid deforestation of moist montane forests.

Many species in the moist montane forests are sources of medicine and honey. A study by Feyera Senbeta et al. (2009b) in some moist montane forests has documented around 50 plant species belonging to 31 families that are recognized by local communities as medicinal plants. Traditionally, these species are used to treat various kinds of ailments of human and livestock such as rabies, viral disease, headache, stomach ache, wound, etc. in different areas. Some of these species include *Argomuellera macrophylla*, *Cassipourea malosana*, *Celtis africana*, *Cucumis jeffreyanus*, *Elaeodendron buchananii*, *Ficus ovata*, *Filicium decipiens*, *Landolphia buchananii*, *Lippia adoënsis*, *Macaranga capensis*, *Maesa lanceolata*, *Mimusops kummel*, *Ocotea kenyensis*, *Paulinia pinnata*, *Pouteria altissima*, *Premna schimperi*, *Rhus ruspolii*, *Ricinus communis*, *Ritchiea albersii*, *Sapium ellipticum*, *Strychnos*...
mitis, Trema orientalis, Trichilia prieuriana, Trilepisium madagascariense, Vernonia leopoldi and Warburgia ugandensis.

Plate 3 In addition to coffee, moist montane forests support various non-timber forest products like honey, spices and medicine

Additionally, across the moist montane forests of Ethiopia over 25 plant species were recorded as important honeybee flora (Feyera Senbeta et al., 2009b). As the majority of honey production in the moist montane forest areas is more of traditional type, these species are highly important to the livelihood of local communities. Some of these species include Albizia schimperiana, A. grandibracteata, Baphia abyssinica, Clerodendrum myricoides, Combretum aculeatum, Ehretia cymosa, Entada abyssinica, Gouania longispicata, Hippocratea africana, Morus mesozygia, Oncinotis tenuiloba, Polyscias fulva and Schefflera abyssinica.
As hydrological and ecological function

As these forests are located on the mountains, they are important in watershed management and as water catchment and erosion barriers, including a role in the capture and transport of water and protection of soils against erosion (Plate 4). All montane forests have an important role in stabilizing water quality and maintaining the natural flow patterns of the streams and rivers originating from them (Umencdeo et al., 1993). Evidence suggests that moist montane forests perform a watershed function that is somewhat different from that performed by other forests. This difference relates to the presence and the occurrence of high precipitation regimes in the regions where moist montane forests occur. The tree crowns act to intercept wind-driven cloud moisture on leaves and branches that drips to the ground. The absolute increase in net precipitation is a result of the presence of trees. This can add to the groundwater and stream flow levels, but its precise effect on the hydrological cycle is difficult to determine. The impact will, in any case, vary from place to place depending on factors such as incidence of wind-driven clouds, wind speed, size and orientation of mountains, altitude, type of vegetation, and other climatic variables (Kerfoot, 1968; Stadtmüller, 1987; Umencdeo et al., 1993).

Plate 4 The hydrological and ecological services of the moist montane forests are witnessed by the purity of the rivers flowing out of the forests

In Ethiopia, most rivers originate from the mountains covered by montane forests. Apparently, montane forests capture and store rainfall and moisture, maintain water quality, regulate river flow, reduce erosion and protect against landslides. In the absence of vegetation, permanent rivers gradually change into intermittent rivers and progressively into dry riverbeds (Gedion Asfaw, 2003).
For example, the Bale mountains area is of significant value to approximately twelve million people that are dependent on its ecological processes, primarily water. The Bale massif with its forest cover is the source of four major rivers – the Wabe Shebelle, Web, Welmel and Dumal. These rivers are the only sources of perennial water for the arid lowlands of the east and southeast of Ethiopia, including the Ogaden and Somali agricultural belt. The livelihood and food security of the people in these lowland areas, particularly during the dry season, are therefore highly dependent on good forest management in the highland areas.

Similarly, the moist montane forests of southwest and west Ethiopia also play a significant role in irrigation and hydropower generation. The water from the river systems (Baro, Didessa, Gibe, Gojeb, Hangar, etc) originating from montane forests is used in several lowland areas of southern and western Ethiopia including Kenya, Sudan and Egypt. For instance, a report by ENTRO (2007) indicated that converting one hectare of forest to agriculture increases the sediment load in the Baro River (southwest Ethiopia) crossing into the Sudan by 25 tons/year. The increased sediment load leads to annual cleaning costs in irrigation canals in the Sudan’s irrigation schemes. A total cost of the additional sediment load caused by the annual deforestation of 28,916 ha of forest is estimated to reach around USD 10.5 million. This is the total net present value of the cumulative sedimentation in irrigation canals and reservoirs caused by annual deforestation within the Baro-Akobo basin in Ethiopia.

If the montane forests are cleared, the deforestation will also enhance soil erosion. Soil erosion resulting in loss of land productivity leads to loss in current and future incomes. For example, the average soil loss rate due to erosion for Kafa area was estimated to be around 12.3 tons/ha/year for cultivated fields (Eyasu Elias, 2003). This shows that the rate of loss is much lower than the national average of 130 tons/ha/year (FAO, 1986) due to the intact forest in the upper watershed of the farm plots. Assuming a complete removal of a forest from an area and taking the national erosion rate for the purpose of valuation and based on current fertilizer prices, the soil conservation value of the moist montane forest is estimated to be ETB 745 per ha/year (Eyasu Elias, 2003).

A major element of the hydrology and ecology of moist montane forests is the abundance of epiphytic plants (Plate 5), which are plants such as mosses, ferns and bromeliads that grow on the trunks and branches of trees. According to Foster (2001), up to a quarter of all moist forest plant species may be epiphytes.
The epiphytes capture water directly from the fogs and clouds and provide a variety of microhabitats for invertebrates, amphibians and their predators (Benzing, 1998). Water storage in epiphytes has been calculated as ranging from 3,000 litres/ha (Richardson et al., 2000) up to 50,000 litres/ha (Sugden, 1981). Up to half the total input of nitrates and other ions and nutrients to the forest would come from water stripped from clouds by epiphytes (Benzing, 1998).

**Threats**

Human beings have been components of Ethiopian forest ecosystems for hundreds and thousands of years. As a result, over-exploitation, ruthless destruction of natural forests as well as degradation of the various habitat types have made montane forests to be the most vulnerable and threatened ecosystem. The direct effect of deforestation results in an increase in soil erosion, siltation and other associated hydrological processes as well. Poverty and population growth are the root cause for habitat destruction. The increasing need to produce more food, fuel wood, shelter and clothing accelerates the rate of deforestation and thereof, environmental degradation. Montane forests seem to have changed substantially in physiognomic structure and species composition.

They are still under continuous threat owing to anthropogenic disturbance due to settlement (Plate 6), expansion of agriculture and logging (Plate 7), and commercial plantations (Plates 8 and 9) of tea/coffee (Tadesse Woldemariam et al., 2002; Feyera Senbeta, 2006; Feyera Senbeta et al. 2009a,b).
Plate 6 Settlement and shifting cultivation practices in the moist montane forests of Ethiopia

Through these activities, montane forests have been and are still, transformed or being fragmented into different land use systems. A study by Dereje Tadesse et al. (2008) in southwest moist montane forests showed that the forest cover close to Mizan Teferi has been reduced from 71% to 48% between the years 1973 and 2005 that makes the overall forest cover loss 30%. The root causes of deforestation identified were political, social or economic, that occurred at various scales. As the study indicated, most farmers converted the forest in their settlement area into agriculture and coffee agroforestry systems.

The improved coffee market system as a result of the free market economy encouraged farmers to practice such coffee planting system over the assessment periods. Traditionally, the indigenous communities of southwest Ethiopia were engaged in hunting, gathering, beekeeping and shifting cultivation of root crops. In most cases, these activities demand small plot of land and the production system is also forest friendly. Following the spread of new settlements and urbanization in the area in the 1970s and 1980s, the overall landscape of the southwest moist montane forest areas has changed quickly due to changes in production system. For the indigenous communities, there is a continuous shift in their feeding habit from tuberous plants to cereal crops. The poor market demand for root crops at national level due to feeding habit of the dominant urban society and difficulty for bulk of transportation hindered the continuous cultivation of tuberous plants in the area (Dereje Tadesse et al., 2008). Thus, the change in consumption pattern contributed to change in farming systems that cause demand for more land.
The government as owner and manager of forest resources has frequently been involved in conflicting activities. On the one hand, the government has been and still is excessively engaged in encouraging farmers in development of export crops and settlement programmes into forestland while on the other hand endorsing different proclamations that support conservation and development of forest resources. The latter action has excluded the local community from exercising their customary land tenure system. In response to such tenure insecurity the local community has aggressively engaged in changing the forest ecosystem into human modified agroforestry system causing forest degradation and loss of biodiversity.

Plate 7 Illegal logging and agricultural expansion in the moist montane forests

Plate 8 Commercial plantation expansion in the moist montane forests, e.g. tea and oil palm
The most striking land use changes in the moist montane forest ecosystem is caused by human activities in the form of timber extraction, coffee and tea plantations development, agricultural expansion, human settlement and sometimes, fire hazards. As a result of selective felling of trees for timber, a few species are targeted and those that are of low commercial value are remaining with few over-matured individuals of high quality timber species. At present, maize and teff cultivation is infringing upon parts of the southwestern Ethiopia, which together with highly leached acidic soils and rugged topography intensify the degradation processes. Forest grazing by livestock in many places has reduced natural regeneration of forest tree species from understory seedlings.

A recent study of the Harenna forest has shown that more than 40% of the understory seedlings are consumed by herbivores, or livestock in particular, only during the dry season of the year (Getachew Tesfaye et al., 2002). Unpredictable wild fire is also becoming a major threat to forest ecosystems of the country. In the year 2000 alone, more than 90,000 hectares of mature forests were damaged by fire, of which the Harenna forest (a moist montane forest) accounted for one third (30,000 ha) of the damage. The country has neither an appropriate policy nor sound strategy to avoid both forest fire and other unpredictable calamities that would help to minimize the impact.

Plate 9 Commercial plantation expansion in the moist montane forests, e.g., coffee
The presence of huge potential for timber, coffee and tea production in the moist montane forest areas have become very much attractive to various investment endeavours. In many places, investors have made huge profits by extracting and selling timber only from the forest and leaving the areas without any tax payment or implementation of their proposed projects. The Bebeka Coffee Plantation Development, which has existed since the 1970s has now become less profitable than the traditionally managed forest coffee.

Over-exploitation, ruthless destruction of natural forests as well as degradation of the various habitat types in moist montane forests has made the area to be the most vulnerable and threatened ecosystem. The increasing need to produce more food, fuel wood, shelter and clothing accelerates the rate of deforestation and therefore, environmental degradation. In general, the loss of forest biological resources as a result of human interference has increased double-fold in terms of national economy, social well being, cultural heritage and environmental health. Babya-Fola, Belete-Gera and Bonga forests lost about 77.4%, 82.8% and 90% of their closed high forest areas, respectively from 1976 to 1990 only, and there is no more closed high forest remaining (Reusing, 1998). The above figure would give a clue as to how our natural forests are depleted as well as the picture about the rates of change in forest cover of the country.

Conservation status

The existing knowledge on the extent of the moist montane forests, their distribution, diversity of their constituent species as well as ecological requirements is very limited. The State Forest Conservation and Development Department of the 1980s designated 58 important forest areas as Natural Forest Priority Areas (NFPAs). The aim of designating NFPAs was for their production, protection and biological conservation services (EFAP, 1994). These areas comprise natural forests, plantations and non-forested lands. Among the National Forest Priority Areas designated for protection of the moist montane forest ecosystem are Harenna-Kokossa, Godare, Gebre Dima, Setema, Sigmo-Geba, Yayu, Babya-Folla, Belete-Gera, Mana-Angetu, Tiro-Botor-Becho, Masha-Anderacha, Bonga and Sheko forests. In some of the NFPAs, no natural high forests are remaining at all, and in most of them the forest stands have been partly deforested or severely degraded in quality and quantity (Reusing, 1998) and there is an urgent need to conserve, protect, manage and replenish the moist montane forests in general and the biological resources in particular.
In addition, a detailed ecological investigation, including structure, composition and diversity of the flora and fauna of this ecosystem is highly required.

The national policy on forest resources of Ethiopia clearly indicated that the high forests (moist montane forests) should be kept primarily for protection and conservation purposes. Commercial utilization, according to the policy, is a secondary objective. However, the present management of the moist montane forests fails to achieve its major primary objective. Actually, the forests have been declining both in quality and quantity at a faster rate in the last two decades than ever before, and the existing forest policies do not seem to have worked at all. None of the NFPAs have legal protection and moreover, the lack of accountability and low level commitment both from the civil service and the political set up aggravated the situation. Therefore, considerable efforts should be made to promulgate appropriate and effective laws that would safeguard the protection and sustainable utilization of the remaining moist montane forest resources. Accurate inventory is also required to assess the extent, distribution and biological diversity of the forest resources. Otherwise, the few remaining natural forest cover will continue to dwindle and finally disappear and the country would suffer from serious environmental degradation while the globe would be losing one of its major ‘Carbon Sinks’.

Conclusion and recommendations

The moist montane forests of Ethiopia have huge environmental and economic values. A transformation of the potential values into real benefits for the local population living in and around the forest is crucial. It is only when values of the forest are recognized that the people are willing to conserve the resources. Importantly, recognition of the forest values by government and other stakeholders has a paramount importance. Therefore, considerable efforts should be made to promulgate appropriate and effective laws that would safeguard the protection and sustainable utilization of the remaining forest resources. Otherwise, the few remaining natural forest patches of the country will be lost sooner or later. In light of these facts, the following points are recommended to improve and prolong the conservation and use of moist montane forests of Ethiopia:

- Since conservation is impossible without appropriate economic incentives, transformation of the potential value of the forest resources into real benefits for the rural population is mandatory. For this to be realised, environmental marketing schemes (e.g., eco-labeling certification of wild coffee, water trading, and carbon trading should be enhanced).
Sustainable uses of non-timber forest products such as spices, honey, coffee, medicinal plants and others should be promoted.

Participatory development of conservation concepts through use of biosphere reserve approach by zoning the forest into different management zones such as core, buffer and transitional zones is highly important. The ‘core zone’ will be devoted to preserving biodiversity with no human interference. Around this core is a ‘buffer zone’ in which non-destructive resource use is allowed, surrounded in turn by an indefinite ‘transition area’ where sustainable development activities are permitted to improve the livelihoods of the local community.

As most of these forests are located on mountains, in addition to their unique diversity in flora and fauna, moist montane forests of Ethiopia have huge ecotourism potential values. In particular, there are several waterfalls, plant and animal resources, coffee and historical and cultural sites that can serve as tourist attractions.

There is also a need for an integration of indigenous knowledge with modern conservation approaches in the planning and implementation process for improving the likely local community participation in the conservation processes. Local knowledge not only provides information on the use of species, but can also contribute to valuable information on how to maintain and conserve the genetic materials, species and ecosystems. Effective conservation and sustainable use of the moist montane forests with wild coffee populations therefore needs the involvement of many stakeholders including local communities.

The most important component of moist montane forest conservation is the rehabilitation of degraded forestlands in and around the forests. On these degraded lands, multipurpose tree species can be introduced that will create alternative livelihood for the local communities. At the same time, these areas buffer the forest conservation zone and promote the sustainable use of forested land.

The country should develop land use policies and planning that promote land use according to suitability. Any rural development strategy should be geared towards multifaceted approaches, which considers rural development based on the carrying capacity of the resource base.

Moreover, continuous studies are required for monitoring and evaluation, and understanding the dynamism of the forests.
References


**FOREST TYPES IN ETHIOPIA**

**EXECUTIVE SUMMARY**

**ACACIA - COMMIPHORA MIXED FORESTS OF ETHIOPIA**

**BAMBOO FORESTS OF ETHIOPIA**

**COMBRETUM-TERMINALIA MIXED WOODY EVERGREEN FORESTS OF ETHIOPIA**

**DRIEDUSSO-MONNANA MIXED MONTANE FORESTS OF ETHIOPIA**

**LOWLAND AND SEMI-MOIST MONTANE EVERGREEN FORESTS OF ETHIOPIA**

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Forum for Environment (FfE)

**FOREST TYPES IN ETHIOPIA**


LOWLAND SEMI-EVERGREEN FORESTS
OF ETHIOPIA

Feyera Senbeta

Introduction

Ethiopia used to possess large forest resources back in due course. According to various sources (e.g., Logan, 1946; von Breitenbach, 1963; EFAP, 1994; Rogers, 1992; Darbyshire et al., 2003; Badeg Bishaw, 2009), high forests and woodlands covered about 60% of the total land area of the country a century ago. In recent decades, however, unregulated agricultural expansion, uncontrolled harvesting and weak institutional capacity have led to the destruction of forests, woodlands and other natural resources across the country (von Breitenbach, 1962; Assefa Kuru, 1990; Rogers, 1992; Darbyshire et al., 2003; Dereje Tadesse et al., 2008). The driving agents responsible for the decline in forest cover in many parts of the country are high population growth, poverty, low agricultural productivity, low living standards and lack of alternative means of livelihood for most of the rural population. Currently, the forest cover in Ethiopia is estimated at less than 4% compared, for example, with an average of 20% for sub-Saharan Africa (Earth Trends, 2007). The current rate of deforestation is estimated to be as high as 5% per year in the country (Reusing, 1998; WBISPP, 2002; Dereje Tadesse et al., 2008).

Among the various vegetation types in Ethiopia, lowland semi-evergreen forests represent a rare and fragile forest ecosystem. In Ethiopia, different authors have named this forest vegetation differently: lowland forest (Chaffey, 1979), lowland evergreen forest (Mesfin Tadesse, 1992), lowland dry peripheral semi-deciduous Guineo-Congolian forest (Friis, 1992), lowland tropical forest and lowland semi-evergreen tropical forest. Hereafter, the name “lowland semi-evergreen forest” is adopted throughout this paper.

The lowland semi-evergreen forest was first described by Chaffey (1979). In his description, he associated the Ethiopian lowland semi-evergreen forest with that of the moist semi-deciduous forest of Ghana and Uganda and the lowland seasonal rainforest of Malawi; and classified it as the Pan-Guineo-Congolian type.
Further description was made by Friis (1992) who named it as “Dry Peripheral Semi-Deciduous Guineo-Congolian Forest type”.

As portrayed by many, the lowland semi-evergreen forest of Ethiopia is restricted to the southwestern corner of the country and covers only a small portion of Gambella Regional State. Importantly, it possesses restricted plant species and is being recognized as part of Ethiopian biodiversity hotspots. However, the Ethiopian lowland semi-evergreen forest is among the most threatened habitats in the country due to rapid clearance for various kinds of agricultural practices. This means that virtually all these unique habitats and associated biodiversity are facing significant threats due to both natural and anthropogenic factors. At present, the country has lost the largest portion of the lowland semi-evergreen forest. Whatever the causes of the problem might be, the bottom line is that conservation efforts are mandatory in order to reverse and maintain the remaining lowland semi-evergreen forest patches in the country. A diverse range of social, economic and ecological information about the forest is necessary to design suitable conservation and sustainable use approaches.

The present paper gives an overview of the status, potential contributions and threats of lowland semi-evergreen forest in Ethiopia, and of the natural and man-made restoration efforts. The analysis is based on data drawn from different sources. Recommendations for conservation of the last remaining lowland semi-evergreen forest of Ethiopia are proposed.

Location and description

The lowland semi-evergreen forests of Ethiopia include a narrow strip of humid forests along the southwestern corner of the country, specifically in Gambella Regional State, with the geographical reference of 6°30’ and 8°00’ (Figure 1). It is located within altitudinal range between 450 and 600 m a.s.l. In particular, it is situated in Abobo, Gog, Godere and Dima districts, covering an area of about 200,000 ha (WBISPP, 2002). Mostly, this forest is located on a nearly flat plain but the eastern part of the forest is located on a broken escarpment penetrated by the valley of the Baro, Gilo and other small rivers. It falls within the watersheds of the Baro and Gilo rivers – the tributaries of the Nile.
Figure 1 Map of Ethiopia showing relative location of lowland semi-evergreen forest in Ethiopia

This lowland semi-evergreen forest area has localized climatic conditions that has resulted in its different vegetation type. It is characterized by unimodal rainfall with mean annual rainfall range of 1,300-2,000 mm (W-E direction), with heavy rainfall during the wet season (May-October) and very little precipitation during the dry season (December-March). The mean maximum and minimum temperature ranges from 35 to 38°C and 18 to 20°C, respectively (Daniel Gemechu, 1977).

Geologically, the eastern part of the forest is located on the Precambrian basement (5000 Mya), the oldest rocks. In other places, the forest is on Pleistocene-Holocene deposits (recent deposit) (0.8-0.01 Mya). Studies by Mohr (1965, 1971) and Kazmin (1972) show the forest area as undifferentiated lying between the two rock deposits. The forest is located on high proportion of silt or sand with mostly well-drained soils. But in some places a deep black clay soil – embedded under the forest floor is encountered.

The major means of livelihood of the people living in and around the lowland semi-evergreen forest is diversifying in recent years. Historically, most of the people living in the area used to depend on forest and forest related products - mainly honey, wild fruits, tuber and hunting. Still hunting on the plains and forest edge is carried out in the dry season, using fire to flush the animals. Fishing is an important source of food. Over the last two to three decades, however, the introduction of different kinds of external interventions into the area has accelerated significant changes in the forest sources and means of livelihood.
Some of these interventions brought permanent agricultural activities as opposed to the previous shifting cultivation practices. Apparently, today, the means of livelihood in the area has expanded beyond traditional system. Rearing livestock is practiced on different levels among the communities.

Forest structure

At the moment, it is not possible to properly describe the structure of lowland semi-evergreen forest because of lack of available data. Despite this constraint, the author has articulated few notes for the sake of readers; but the readers should take into account the incompleteness of the information given below about structure of the forest.

Forest or vegetation structure can be characterized using size-class distribution, density, basal area and stratification. Most plant communities consist of a large number of species and hence it is not possible to include all species in a survey. Woody plants are only therefore used for the structural analysis description in most cases. Here, woody plant density, vertical stratification, and size class distribution are used only to describe the structure of the lowland semi-evergreen forest.

Data sources used for this brief description are mainly drawn from FGRP (2002a). A study in Abobo-Gog lowland semi-evergreen forest showed the density of trees and shrubs to be around 1,579 individuals per ha. The highest stem density per ha was recorded for Baphia abyssinica, Argomuellera macrophylla and Acalypha ornata. The highest stem density was found in the lower story and the lowest in the upper story. The height and diameter class distribution in Abobo-Gog lowland semi-evergreen forest also showed normal patterns of distribution. In both cases, density decreased uniformly as diameter and height class increased. The density of individuals with diameter at breast height (dbh) greater than 10 cm was around 393 individuals per ha. In the Abobo-Gog lowland semi-evergreen forest, the largest diameter recorded was 220 cm for Milicia excelsa whereas the maximum height recorded was 40 m for Pouteria alnifolia. On the other hand, the total basal area recorded in this lowland semi-evergreen forests was around 30 m² per ha.

Floristic composition

A floristic study of lowland semi-evergreen forest was made by few researchers (e.g., Chaffey, 1979; Friis, 1992; Tesfaye Awas et al., 2001; FGRP, 2002a). Even some of these studies are a kind of exploration and hence is very difficult at this point to correctly estimate the floristic composition of the forest.
Studies by Chaffey (1979) and Friis (1992) focused on forest description rather than complete floristic listing. On the other hand, a study by Tesfaye Awas et al. (2001) covered beyond lowland semi-evergreen forest including the surrounding woodlands, and hence the use of the data can only serve as baseline information. According to FGRP (2002a), a total of 106 woody species belonging to 33 families were recorded from the lowland semi-evergreen forest, Abobo-Gog forest. A conservative estimate of the higher plants of lowland semi-evergreen forest could be around 500 species, but there is a need to make a complete floristic list of this forest for any future conservation interventions.

The Ethiopian lowland semi-evergreen forest is characterized by the presence of certain tree species that are widely distributed in tropical Africa, but in Ethiopia the species are confined to southwestern lowland area. These species are largely Guineo-Congolian species (Friis, 1992). In its physiognomic feature, the lowland semi-evergreen forest is comparable with moist montane forest described earlier although it varies in its composition.

The lowland semi-evergreen forest of Ethiopia can be stratified into two to three like the moist montane forest. The emergent canopy occupies the layer above 30 m height and is usually discontinuous. Emergent canopies are characteristically made up of a mixture of Antiaris toxicaria, Alstonia boonei, Milicia excelsa, and Celtis integrifolia. The most frequent canopy tree species of the lowland semi-evergreen forest include Baphia abyssinica, Blighia unijugata, Celtis gomphophylla, C. philippensis, Diospyros abyssinica, D. mespiliformis, Ficus spp., Lecaniodiscus fraxinifolius, Pouteria alnifolia, Morus mesozygia, Strychnos mitis, Trichilia perieuriana, and Zahna golungensis.

The most frequent smaller tree species include Argomuellera macrophylla, Bridelia micrantha, Erythroxylum fisheri, Oxyanthus speciosus, Schrebera alata, Tapura fisheri, Teclea nobilis, Vepris dainelli and Whittingfieldia elongata. Some of the most frequent lianas include Acacia pentagona, Cissampelos mucronata, Hippocratea africana, H. pallens, Paullinia pinnata, Tiliacora troupini, Toddalia asiatica and Uvaria spp. Epiphytes are commonly rare and some of the common ones include Aerangis luteola, Arthrophytis monoponcarpa, Asplenium aethopicum, A. sandersonii Loxogramme abyssinica, and Peperomia tetraphylla.
Biodiversity features

In the Ethiopian context, lowland semi-evergreen forest has very high levels of endemism and is home to many restricted or threatened species. Hence, the importance of lowland semi-evergreen forest of Ethiopia for biodiversity conservation is significantly high (Chaffey, 1979; Friis, 1992; WBISPP, 2002). Most lowland semi-evergreen forest species are often restricted in their range of distribution. Hence, lowland semi-evergreen forest of Ethiopia can serve as a gene reserve for many of these useful forest species.

Plant diversity. The lowland semi-evergreen forest is characterized by the presence of certain tree species, which are widely distributed in tropical Africa. In Ethiopia, the majority is confined to the lowland area (Chaffey, 1979; Friis, 1992). A study by Forest Genetic Resources Project (FGRP, 2002a) reported that Abobo-Gog lowland semi-evergreen forest has more than 106 woody plant species including lianas. This is only partial information, and if exhaustively recorded the plant diversity of all plant forms in this forest could be much higher and diverse. Hence, there is a need to make a complete plant diversity (both higher and lower plants) assessment in the lowland semi-evergreen forest of Ethiopia for any biodiversity conservation issues.

Animal diversity. Several animal species are known to inhabit the lowland semi-evergreen forest ecosystem although intensive scientific investigations are lacking. Larger mammals living in this ecosystem include among others, buffalo, bush pig, bushbuck, civet, common jackal, defassa waterbuck, duiker, elephant, giant forest pig, hippopotamus, lelwel hartebeest, leopard, lion, Nile lechwe, olive baboon, roan antelope, crocodile, tortoise, wart hog, giraffe, white-eared kob, wild dog and others. Although a complete inventory is lacking, the lowland semi-evergreen forest fragments are believed to support high bird species including ostriches, pelicans, herons, egrets, storks, ibis and geese.

The importance of lowland semi-evergreen forest

Lowland semi-evergreen forest exhibits many ecological and socioeconomic values and functions (Figure 2). In addition to economic importance, all forests help maintain the environmental conditions that make life possible - from regional hydrologic cycles to global climate. Forest ecosystems store tremendous amounts of carbon. Without these forests, this carbon would go straight into the atmosphere as carbon dioxide, a powerful greenhouse gas. Protecting and responsibly managing the last remaining lowland semi-evergreen forest today will help avoid paying the high costs associated with massive forest loss and degradation.
As sources of livelihood

Many people living in and around the lowland semi-evergreen forest are receiving various means of livelihood directly or indirectly from the forest. The major livelihood sources include wild food, medicine, farm tools, fuel wood, furniture, house construction material and others. The major contribution of lowland semi-evergreen forest to rural livelihood is briefly described as follows:

**Honey.** For local community living in and around lowland semi-evergreen forest, honey production plays a significant role in their livelihoods. Honey is produced in the area both for home consumption and income generation. The forest provides bee forage, nesting habitat for honeybees and materials to make hives. Honey collection is a traditional type (beehives are hanged on trees in the forest) in the area and honey is collected both from hanged beehives and hollow trees. Trees that are preferred for hanging beehives include Antiaris toxicaria, Celtis toka, Combretum adenogonium, Ficus dicranostyla, Tamarindus indica, Trichilia emetica and Ziziphus pubescens, among others.
Plate 2 Some tree species in the lowland semi-evergreen forest grow magnificently both tangentially and vertically, e.g., Antiaris toxicaria

As hydrological and ecological function

As this lowland semi-evergreen forest is located on the escarpment and plains, they have an important role in watershed management and as water catchment and erosion barriers, including a role in the capture and transport of water and protection of soils against erosion. The lowland semi-evergreen forest has an important role in stabilizing water quality and maintaining the natural flow pattern of the streams and rivers originating from them (Umencdeo et al., 1993). Studies suggested that the lowland semi-evergreen forest of Ethiopia has a watershed function. As this forest is located on a high precipitation belt, in the absence of this forest the impact of rainfall and related problems would have been much higher and serious. The tree crowns act to intercept wind-driven cloud moisture on leaves and branches that drips to the ground. The absolute increase in net precipitation is a result of the presence of trees. This can add to the groundwater and stream flow levels (Plate 3).
Plate 3 Hydrological and ecological roles of the forest can be witnessed by looking at the purity of the rivers flowing through the forest

Currently, the lowland semi-evergreen forest of Ethiopia is estimated to cover around 200,000 ha. Using this forest cover and global valuation set for different forest service types, the lowland semi-evergreen forest of Ethiopia has high values. Table 1 shows the annual economic value of lowland semi-evergreen forest of Ethiopia. On the basis of economic evaluation, the forest can have a value of around USD 313,800,000.00 annually.

Additionally, the lowland semi-evergreen forest is currently supporting different irrigation schemes indirectly. The water from the river systems (Baro, Gilo, etc.) originating or passing through the lowland semi-evergreen forest is used in several lowland areas of western Ethiopia and the Sudan. For instance, a report by ENTRO (2007) indicated that converting one hectare of forest to agriculture increases the sediment load in the Baro River (southwest Ethiopia) crossing into the Sudan by 25 tons/year. The increased sediment load leads to annual cleaning costs of irrigation canals in the Sudan's irrigation schemes.
Table 1. Annual economic value of lowland semi-evergreen forest of Ethiopia (200,000 ha was used for calculation)

<table>
<thead>
<tr>
<th>Forest service type</th>
<th>Global Value of (USD/ha)*</th>
<th>values lowland semi-evergreen forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate regulation</td>
<td>223</td>
<td>44,600,000.00</td>
</tr>
<tr>
<td>Water regulation</td>
<td>6</td>
<td>1,200,000.00</td>
</tr>
<tr>
<td>Water supply</td>
<td>8</td>
<td>1,600,000.00</td>
</tr>
<tr>
<td>Erosion control and sediment retention</td>
<td>245</td>
<td>49,000,000.00</td>
</tr>
<tr>
<td>Soil formation</td>
<td>10</td>
<td>2,000,000.00</td>
</tr>
<tr>
<td>Nutrient cycling</td>
<td>922</td>
<td>184,400,000.00</td>
</tr>
<tr>
<td>Genetic resources</td>
<td>41</td>
<td>8,200,000.00</td>
</tr>
<tr>
<td>Recreation</td>
<td>112</td>
<td>22,400,000.00</td>
</tr>
<tr>
<td>Cultural</td>
<td>2</td>
<td>400,000.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>313,800,000.00</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Source: Krieger, 2001

Threats

Long years of anthropogenic factors have seriously affected forest cover in Ethiopia. In many parts of the country, over-exploitation, agricultural expansion, fire and poor sighted development initiatives have threatened many forests. Parts of the drivers of these problems are usually poverty and population growth. The increasing need to produce more food, fuel wood, shelter and clothing accelerates the rate of deforestation and thereof, environmental degradation. Ethiopian lowland semi-evergreen forest has not escaped these problems.

In recent years, the continuous deforestation owing to settlement expansion (Plate 4), fire, shifting cultivation, and commercial plantations are the major issues. These problems are expanding severely. Traditionally, the indigenous communities (e.g., Mejengir, Anuak) who live in and around the forest used to practise hunting and gathering for a living. However, over time, these types of livelihood systems have been replaced, and settlement and extensive farming have taken over a large area of the forest.
In addition, mass migration and increased development activities in the area have brought about serious threat to the forest cover over the last two to three decades.

Plate 4 Settlement expansion into the forest is a common phenomenon

Alongside this, the century long practice of shifting cultivation in the area has also affected the forest significantly (Plate 5). As reported by Chaffey (1979), forest clearance appears to have increased considerably during that time due to agricultural requirements.

Plate 5 Shifting cultivation has been practiced for generations in the lowland semi-evergreen forest
Fire has also played a considerable role in influencing the condition of the lowland semi-evergreen forest. The use of fire for agricultural field preparation or for other purposes has brought about immense pressure on the lowland semi-evergreen forest (Plate 6).

Plate 6 Forest fire, a common problem in the lowland semi-evergreen forest

Causes of deforestation are diverse, complex and act in various combinations or synergies in different areas. Therefore, reversing deforestation and degradation is complicated by multiple causal factors including conversion for agricultural use, infrastructure extension, commercial plantation expansion (Plate 7), wood extraction, and a complex set of additional governance and place-specific factors. A study by WBISPP (2002) indicated that over 30% of the lowland or other vegetation types have been lost over the last two to three decades in Gambella region alone. Although the country has forest policy and strategies, implementation is mostly weak due to lack of strong political will for forest conservation. In most cases, policies give emphasis to the production of crops at the expense of forestland. In this regard, there is a big interest by the government to expand agricultural investment (e.g., rubber plantation, palm oil plantation and biodiesel) into southwest forestlands of Ethiopia including the lowland semi-evergreen forest in recent years. If most of these investment projects are to be implemented as planned they are going to eat and destroy hundreds and thousands of forestlands in the area. The problem of forest destruction of the lowland semi-evergreen forest needs to be addressed as urgently as possible if this natural vegetation is to be saved from loss.
Plate 7 Commercial plantation expansion e.g. oil palm

Conservation status

The existing knowledge on the extent of the lowland semi-evergreen forest, its distribution, diversity of its constituent species as well as ecological requirements is very limited. The Department of Forestry of the Ministry of Agriculture designated 58 National Forest Priority Areas in early 1980s. The aims of designating these forests were for their production, protection and biological conservation services (EFAP, 1994). Among these designated forest areas, the lowland forests of Abobo, Godere and Gog were the major ones. As reported by Reusing (1998), in some of the designated forest areas, significant proportion of the forests were lost because of deforestation and degradation - where threats on lowland semi-evergreen forest were mentioned as serious problems.

The National policy on forest resources of Ethiopia clearly indicated that the high forests (e.g., lowland semi-evergreen forest) be kept primarily for protection and conservation purposes. Commercial utilization, according to the policy, is a secondary objective. However, the present management of the lowland semi-evergreen forest fails to achieve its major primary objective. Actually, the forest has been declining both in quality and quantity at a faster rate in the last decade than ever before, and the existing forest policies do not seem to have worked at all. Therefore, considerable efforts should be made to promulgate appropriate and effective laws that would safeguard the protection and sustainable utilization of the remaining lowland semi-evergreen forest resources.
Accurate inventory is also required to assess the extent, distribution and biological diversity of the forest resources. Otherwise, the remaining natural forest cover will continue to dwindle and finally disappear and the nation would suffer serious environmental degradation while the globe would be losing one of its major 'Carbon Sinks'.

Conclusion and recommendations

The lowland semi-evergreen forest of Ethiopia has huge environmental and economic values. A transformation of the potential values into real benefits for the local population living in and around the forest is crucial. It is only when values of the forest are recognized that the people are willing to conserve the resources. Importantly, recognition of the forest values by the government and other stakeholders has a paramount importance. Therefore, considerable efforts should be made to disseminate appropriate and effective laws that would safeguard the protection and sustainable utilization of the remaining forest resources. Otherwise, the few remaining natural forest patches of the country will be lost sooner or later. In light of these facts, the following points are recommended to improve and prolong the conservation and use of lowland semi-evergreen forests of Ethiopia:

- Since conservation is impossible without appropriate economic incentives, transformation of the potential value of the forest resources into real benefits for the rural population is mandatory. For this to be realised, environmental marketing schemes (e.g., water and carbon trading should be enhanced).
- Sustainable uses of non-timber forest products such as honey, traditional medicine and others should be promoted.
- Promotion of ecotourism should be developed. As this forest has unique floral and faunal diversity there is a huge ecotourism potential for development. In particular, there are waterfalls, plant and animal resources and historical and cultural sites that can serve as tourist attractions.
- There is also a need for an integration of indigenous knowledge with modern conservation approaches in the planning and implementation process for improving the likely local participation in the conservation processes. Local knowledge not only provides information on the use of species but can also contribute to valuable information on how to maintain and conserve the genetic materials, species and ecosystems.
• The most important component of lowland semi-evergreen forest conservation is the rehabilitation of degraded forestland in and around the forest. On these degraded lands, multipurpose tree species can be introduced that will create alternative livelihood for the local communities. At the same time, these areas buffer the forest conservation zone and promote the sustainable use of forested land.
• The country should develop land use policies and planning that promote land use according to suitability. Any rural development strategy should be geared towards multifaceted approaches, which would consider rural development based on the carrying capacity of the resource base.
• Moreover, continuous studies are required to monitor and understand the dynamism of the forests.

References


FfE has been registered and licensed by the Charities and Societies Agency as an Ethiopian Residents Charity. It serves as a platform for environmental communication and advocacy among people concerned with the Ethiopian environment.

In order to carry out its mandate, FfE organizes public meetings and debates on issues of environmental and climate change concern; publishes a magazine (Akirma) and information dossiers; prepares speaking engagements; conducts researches; facilitates access to advisory services; creates and joins networks; establishes and strengthens local groups in various parts of the country; undertakes lobbying and campaigning; and acts as a liaison for funding projects that focus on protecting or improving the environment.

Furthermore, FfE currently hosts the Ethiopian Civil society Network on Climate Change (ECSNCC) that consists of 60 member organizations working on climate change issues. Since its establishment FfE has been actively engaged in drawing the attention of citizens to the severity of environmental challenges in the country and promoting solutions to the challenges.
The year 2011 is declared as the 'International Year of Forests' by the United Nations to raise awareness and strengthen sustainable forest management, conservation and sustainable development of all types of forests for the benefit of current and future generations.
FOREST TYPES

in Ethiopia

Status, Potential Contribution and Challenges

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