Biodiversity Status in Ethiopia and Challenges

Azamal Husen
V.K. Mishra
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**3**

**Biodiversity Status in Ethiopia and Challenges**

Azamal Husen, *Ethiopia*
V.K. Mishra, *India*
Kamal Semwal, *Ethiopia*
Dinesh Kumar, *India*

**ABSTRACT**

Ethiopia is rich in faunal, floral and microbial diversity. Conservation paradigms, practices and policies have been variably successful. Traditional approaches in conservation have evolved awareness about biodiversity conservation. Climate change poses unknown fear and challenge to biodiversity conservation in the 21st century. There is urgent need of mapping of biodiversity in various environments, inventory, monitoring of biodiversity, and global data sharing. Conservation of genetic resources will assist in future genetic improvement of crop plants and livestocks. Bioprospecting—value addition to biodiversity will provide economic gain for the country. Necessary measures need to be initiated to safeguard the germplasms against potential threat to biopiracy. National legislations—for access and benefit sharing, and trans-boundary movement of germplasms need to be ensured to safeguard the interest of the country. Ethiopia needs to harmonise International and National laws in biodiversity conservation. A new thrust in biotechnology, nanotechnology and information and communication technology can contribute technologies to resolve key concerns related to agriculture, enabling food safety, controlling plant and animal diseases, ensuring environmental safety and sustainable use of natural resources.
**INTRODUCTION**

The earth is bestowed with so much diversity in myriad forms, which is important for our very existence on the planet. The variety of genes, species and ecosystems are various components of biological diversity, which is important to mankind for various reasons. This includes: source of food, timber, medicines, and fiber etc., support functions, such as flood control, climate regulation, and nutrient cycling, resilience to disturbance and environmental change, source of pollinators and pest control in agriculture and, carbon storage and sequestration, economic, recreational, human health benefits and social contributions. Biodiversity is seen as interdisciplinary science (involving ecological and population biology as well as systematics), and as socio-political activity (because of anthropocentric focus of Convention of Biological Diversity) (Vane-Wright, 1996). Human domination of Earth's ecosystems markedly reducing the diversity of species within many habitats worldwide, and is accelerating extinction (Vitousek et al., 1997). Conservation and sustainable use of biodiversity is fundamental to ecologically sustainable development. The Convention on Biological Diversity, of which Ethiopia is a signatory, advocates that every country has the responsibility to conserve, restore and sustainable use the biological diversity within its jurisdiction. Loss of biodiversity has serious economic and social costs for any country. While following the path of development, Ethiopia has been sensitive to needs of conservation. Ethos of conservation and harmonious living with nature is very much ingrained in the lifestyles of Ethiopia's people. There has been growing part of realization in society that natural resources provide base for economic and social development. Drought and desertification have far reaching adverse impacts on human health, food security, economic activity, physical infrastructure, natural resources and the environment, and national and global security.

**DEFINING BIODIVERSITY**

A concern for environmental protection has been in diverse forms in different countries throughout world. As a consequence of industrial revolution in late 18th century has resulted in environmental movements in Europe. The Post-Green revolution has resulted in adverse environmental effects which have raised widespread environmental concern. Subsequently, we have witnesses massive concern expressed at International forum for protection of environment. The International Union for the Protection of Nature (or IUPN) was founded in 1948 following an international conference in Fontainebleau, France. The organization changed its name to the International Union for Conservation of Nature and Natural Resources in 1956 with the acronym IUCN. The new word ‘biodiversity’ was coined by Walter G. Rosen in 1986 during ‘National forum on Biodiversity’ held in
Washington D.C. under the auspices of the U.S. National Academy of Sciences and the Smithsonian Institute (Takacs, 1996). The big milestone in preservation of nature was “United Nations Conference on Environment and Development”—the Earth Summit held in Rio de Janerio (1992). The Convention on Biological Diversity (CBD), also known as Biodiversity Convention, an internationally binding treaty was opened for signature at the Earth Summit, which provided global framework for conservation of biodiversity.

‘Biological diversity’ or ‘biodiversity’ can have many interpretations. There exists a bone of contention between its biological roots and as a political issue with as many meanings as it has advocates (Redford and Sanderson, 1992). Biological diversity or biodiversity has been defined by the ‘Convention on Biological Diversity’ (CBD) as ‘the variability among living organisms from all sources, i.e. terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part. According to World Resources Institute, World Conservation Union, and United Nations Environment Programme, ‘Global Biodiversity Strategy (1992), biodiversity is the totality of genes, species, and ecosystems in a region. It encompasses diversity within species, between species, and of ecosystem. In most common sense biodiversity is about gene, species and ecosystem.

Despite some success in conserving biodiversity at the local level, the biodiversity continues to decline due to continued increase in human population, resource consumption, market factors and policies. Ethiopian biodiversity, being having unique combination of gene/genotypes, are well selected against environment since ages. Looking at the climate change, these germplasms are going to be highly relevant for rest of the world. Dwindling resources of sustenance will have serious ecological, social and economic implications. Therefore, preservation floral and faunal and microbial diversity is major concern in Ethiopia. This paper attempts to highlight endangerment to biodiversity in Ethiopia, a few of which are likely to become extinct in the near future if protective measures are not taken.

**Biodiversity in Ethiopia**

The major physiogeographic features are massive highland mountains and plateau divided by the Great Rift Valley and surrounded by lowlands along the periphery. The Great Rift Valley runs from northeast from Eritrea to Kenya, in the south creating a vast depression. There is great altitudinal variation from 116 metres below sea level to 4620 metres above sea level. Although Ethiopia is a tropical country with typically hot and dry lowland areas, it has varied macro and micro-climatic conditions. The rainfall is variable in different parts, highest 2200 mm in highlands (>1500 metres) and lowest, 250 mm in lowlands (<1500 metres). All these factors have contributed to richness of Ethiopian biodiversity with great level of endemism and genetic diversity (Figure 3.1).
Fig. 3.1: Provenance of Ethiopia which has been extensively used for phyto-geographical distribution

Key:
AF Afar  GJ Gojjam  SU Shewa
AR Arsi  HA Hararghe  TU Tigray
BA Bale  IL Illubabor  WG Wollega
GD Gondar  KF Keffa  WU Wello
GG Gamo Goffa  SD Sidamo

COMPONENTS OF ETHIOPIAN ECOSYSTEMS

Conservation of habitat diversity leads to conservation of species and genetic diversity. The major ecosystems include: Afroalpine and subafroalpine, Montane dry forest and scrub, Montane moist forest, Acacia-Comiphora woodland, Combretum-Terminalia woodland, Lowland humid forest, Aquatic, wetland, Montane grassland, and Desert and semidesert ecosystems (http://etflora.net). The country has two biodiversity hotspots, the Horn of Africa, and the Ethiopian Highlands, which is a part of Eastern Afromontane hot spot (Biodiversity hotspots). The existence of diverse ecosystems has resulted in rich floral, faunal, and microbial diversity. A good account of Ethiopia biodiversity is available the country reports submitted to secretariat CBD, FAO reports, and documentation of biodiversity through internet sources.
Floristic Diversity

The flora of Ethiopia is very diverse with an estimated number between 6,500 and 7,000 species of higher plants, of which about 15 per cent or more are probably endemic Ethiopia is considered as the fifth largest floral country in tropical Africa (http://chora.virtualave.net/biodiversity.htm). The richness and endemicity of the floral biodiversity have been noted by many workers (Friis et al., 2001; Thulin, 2004; Vivero, 2003; Williams et al., 2004; Husen 2006). The horn of Africa (Ethiopia, Eritrea, Djibouti and Somalia) is a major centre of plant diversity and endemism (Davis et al., 1994), harbouring more than 8000 plant species, with 24 per cent endemic to the region (Friis et al., 2003).

Forest Plant Diversity

The revised estimate of the closed forest cover of Ethiopia is less than 3.5 per cent (Anonymous, 2004). There are about 300 tree species known to be reported in Ethiopia. Recently, Vivero et al. (2005) have compiled a Red List of plants for Ethiopia and Eritrea, of which some important species which require immediate attention has been listed in Tables 3.1, 3.2, Figures 3.2 and 3.3. (See on pages 36 to 55)

Diversity of Crop Plant Species

Ethiopia is one of the richest centres in the world in terms of crop diversity ever since the exploration by collector N.I Vavilov in the 1920s. Crop plants such as coffee (Coffea arabica), Safflower (Carthamus tinctorius), tef ((Eragrostis tef)), noug (Guizotia abyssinica), anchote (Coccinia abyssinica), enset (Ensete ventricosum) etc. are known to have originated in Ethiopia. Local cultivars/farmers varieties of several major food crops (wheat, barley, sorghum, pea, faba bean), regional food crops (Tef, noug, Ethiopian mustard, enset, finger millet, cowpea, lentil), industrial crops (linseed, castor and cotton), forage species (clovers, medics, oats), and cash crop (coffee) are having enormous genetic diversity are available in the Ethiopia. Genetic resources of plants are very much important for future crop improvement programmes.

Faunal Diversity

Ethiopia is rich in faunistic diversity with mammals (277 spp.), birds (861 spp.), reptiles (78 spp.), amphibians (54 spp.) and fishes (101 spp.). Among these some species are in critically endangered, endangered and vulnerable list, therefore there is urgent need to prioritize their conservation in national programmes (See Fig. 3.4 on page 56). Domestic animal species further adds to secondary faunal diversification in Ethiopia. The number of domestic breeds by species a total of 109—ass (6), cattles (31), chickens (14), dromedary (5), goat (26), horse (1), and sheep (26). However, not much information is available on diversity of invertebrates.
<table>
<thead>
<tr>
<th>Name of Plants</th>
<th>Family</th>
<th>Comments</th>
<th>Ethiopian Provinces</th>
<th>Level of Threat (as per IUCN, 2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acacia baazzanii</em> Pic.-Serm.*</td>
<td>Leguminosae</td>
<td>This woodland tree species grows at altitudes of 1350-2400 m.</td>
<td>TU, GD, Gj, SU</td>
<td>EN</td>
</tr>
<tr>
<td><em>Acacia bretschtdiana</em> Chiov.</td>
<td>Leguminosae</td>
<td>A shrub of dry scrub vegetation at low altitude, this species is only known from two type collections</td>
<td>HA</td>
<td>CR</td>
</tr>
<tr>
<td><em>Acacia negrii</em> Pic.-Serm.</td>
<td>Leguminosae</td>
<td>A tree of upland wooded grassland, where it grows at altitudes of 1800-3100 m.</td>
<td>GD, WU, GJ, SU, HA, SD</td>
<td>VU</td>
</tr>
<tr>
<td><em>Acacia prasinata</em> A. Hunde</td>
<td>Leguminosae</td>
<td>A tree species known only from areas of dry woodland or semidesert bushland in Afar and Shewa, growing at altitudes of 900-1300 m. Its habitat is vulnerable to overgrazing and cutting for fuelwood. It occurs in Awash National Park.</td>
<td>AF, SU</td>
<td>CR</td>
</tr>
<tr>
<td><em>Acacia pseudonigrescens</em> Brenan &amp; Ross</td>
<td>Leguminosae</td>
<td>A tree species with a very restricted range known only from a limestone area of succulent shrubland at 300-400 m on the track to Kelafo in the Ogaden. The area, although susceptible to degradation, is relatively unthreatened.</td>
<td>BA</td>
<td>CR</td>
</tr>
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</thead>
<tbody>
<tr>
<td><em>Acacia venosa</em> Hochst. ex Benth.*</td>
<td>Leguminosae</td>
<td>A woodland tree species confined to parts of west Eritrea, Tigray and Gondar on the high plateau where the majority of the Ethiopian population lives. It grows at altitudes of 1900-2400 m. The northern forests have diminished most noticeably because of the expansion of farmed land, increased human habitation and overcutting for fuelwood.</td>
<td>TU, GD</td>
<td>CR A2cd+B1ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Acalypha marissima</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td>A shrub that grows on open or forested slopes at altitudes of 1900-2050 m.</td>
<td>WX</td>
<td>CR B1ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Acanthus sennii</em> Chiov.</td>
<td>Acanthaceae</td>
<td>This shrub is found in areas of <em>Juniperus-Podocarpus</em> forest, along roadsides and in grassland, usually in rocky places. It occurs at altitudes of 1700-3200 m.</td>
<td>GD, GJ, WG, SU, HA, AR, BA, KF, GG, SD</td>
<td>NT</td>
</tr>
<tr>
<td><em>Argyrolobium schimperianum</em> A. Rich</td>
<td>Leguminosae</td>
<td>A shrub of upland bushland and grassland, growing at 2100-3500 m.</td>
<td>TU, GD, GJ, SU</td>
<td>EN B1ab (i,iii)</td>
</tr>
<tr>
<td><em>Barleria grandis</em> Hochst. ex Nees*</td>
<td>Acanthaceae</td>
<td>A shrub species that occurs in woodland habitats along river valleys at altitudes of 1600-1800 m.</td>
<td>TU, GD, SU, WG, KF</td>
<td>VU A2c+B1ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Barleria longissima</em> Lindau</td>
<td>Acanthaceae</td>
<td>A shrub species known only from the type specimen collected in 1893.</td>
<td>SD</td>
<td>CR B1ab (i, iii, iv)+B2ab (i, iii, iv)</td>
</tr>
<tr>
<td><em>Bectium forskorum</em> (Gurke) Chiov. ex Lanza</td>
<td>Lamiaceae</td>
<td>A shrub of <em>Acacia-Commiphora</em> woodland, found on rocky slopes on limestone at 1700-1800 m.</td>
<td>BA</td>
<td>VU B2ab (i, ii, iii, iv)</td>
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<tr>
<td><em>Becium grandiflorum</em> (Lam.) Pic. Serm.*</td>
<td>Lamiaceae</td>
<td>This shrub grows in mountain bushland, pastures and rocky slopes at 1600-3100 m.</td>
<td>TU, GD, WU, SU, WG, SD</td>
<td>NT</td>
</tr>
<tr>
<td><em>Blepharis cuspidata</em> Lindau</td>
<td>Acanthaceae</td>
<td>A shrub species known only from the type collected in <em>Acacia-Commiphora</em> bushland on rocky slopes at 700-800 m.</td>
<td>SD</td>
<td>CR B1ab (i, iii, iv) + B2ab (i, iii, iv)</td>
</tr>
<tr>
<td><em>Blepharispermum obovatum</em> Chiov.</td>
<td>Asteraceae</td>
<td>This shrub species has only been collected once, at altitudes of 500-1000 m on plateaux between El Mara and Mt Ello.</td>
<td>BA</td>
<td>CR B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Boswellia ogadensis</em> Vollesen</td>
<td>Burseraceae</td>
<td>A distinct but little-known tree species that is recorded only from the type locality near the Webi Schebele-river in Kelafo at 300-400 m. It is confined to a small but relatively undisturbed area of <em>Acacia-Commiphora</em> bushland on rocky limestone slopes. It yields a resin that can be used as incense.</td>
<td>HA</td>
<td>CR B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Boswellia pirottiae</em> Chiov.</td>
<td>Burseraceae</td>
<td>Populations of this tree are isolated and restricted to woodland on steep rocky slopes along the Tekeze, Abay and Gibe river systems. They grow at altitudes of 1200-1800 m. Human population and agricultural activities are increasing in the area.</td>
<td>GD, GJ, WU, SU, KF</td>
<td>VU A2c</td>
</tr>
<tr>
<td><em>Cadaba divaricata</em> Gilg</td>
<td>Capparidaceae</td>
<td>A shrub that has a scattered distribution in <em>Acacia-Commiphora</em> bushland at altitudes of 300-400 m.</td>
<td>SD, HA</td>
<td>VU B2ab (ii, iv)</td>
</tr>
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<tbody>
<tr>
<td><em>Cladostigma nigistiae</em></td>
<td>Convolvulaceae</td>
<td>A shrub of <em>Acacia-Commiphora</em> woodland growing at altitudes of 750-1440 m on stony limestone ridges and granite outcrops. It can be found 19 km north-west of Bogol Mayo, on the road from Dolo to Filtu.</td>
<td>SD</td>
<td>EN B2ab (ii, iv)</td>
</tr>
<tr>
<td><em>Commiphora monoica</em></td>
<td>Burseraceae</td>
<td>A tree known only from five collections around the Sof Omar caves. It grows in dense <em>Commiphora</em> bushland on rocky limestone slopes at altitudes of 1250-1400 m. It is the only wholly monoecious species in the genus.</td>
<td>BA</td>
<td>CR</td>
</tr>
<tr>
<td><em>Schweinf. subsp.</em></td>
<td>Leguminosae</td>
<td>A shrub of forest margins and heath scrub, growing at 2000-3400 m.</td>
<td>SU, HA, IL, AR, GG</td>
<td>NT</td>
</tr>
<tr>
<td><em>Crotalaria agatiflora</em></td>
<td>Leguminosae</td>
<td>From the Kefa, Shewa, Bale and Sidamo regions, this small tree occurs in the margins of upland forest or bamboo thicket above 3000 m.</td>
<td>SU, BA, KF, SD</td>
<td>EN B1ab (i, iii)</td>
</tr>
<tr>
<td><em>Schweinf. subsp.</em></td>
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<tr>
<td><em>Crotalaria exaltata</em></td>
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<tr>
<td><em>Polhill</em></td>
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<tr>
<td><em>Crotalaria intonsa</em></td>
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<tr>
<td><em>Polhill</em></td>
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<tr>
<td><em>Crotalaria rosenii</em></td>
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<tr>
<td>(Pax) Milne-Redh. ex Polhill</td>
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<tr>
<td><em>Leguminosae</em></td>
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<tr>
<td>Crotalaria sacculata Chiov.</td>
<td>Leguminosae</td>
<td>A shrub of upland grassland and dry evergreen forest on the Mega plateau, occurring at 1800-2100 m.</td>
<td>SD</td>
<td>CR A2c + B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td>Cussonia ostinii Chiov.</td>
<td>Araliaceae</td>
<td>This tree species occurs abundantly in deciduous woodland and montane grassland at altitudes of 1500-2300 m in the west of the country. Increasing human population and their activities threaten the habitat to some extent, especially in the north of its range.</td>
<td>WU, GD, GJ, WG, IL, AR, KF, GG</td>
<td>NT</td>
</tr>
<tr>
<td>Delosperma abyssinica (Regel) Schwantes</td>
<td>Aizoaceae</td>
<td>A shrub confined to basaltic outcrops.</td>
<td>TU</td>
<td>CR B1ab (i, ii, iii)</td>
</tr>
<tr>
<td>Delosperma schimperi (Engl.)</td>
<td>Aizoaceae</td>
<td>A shrub confined to basaltic outcrops occurring at 3550-4110 m on Mt Erareta.</td>
<td>TU, WU</td>
<td>EN B1ab (i, ii, iii)</td>
</tr>
<tr>
<td>Dombeya kefaensis Friis &amp; Bidgood</td>
<td>Sterculiaceae</td>
<td>A shrub of forest margins and evergreen bushland, recorded just north of the Gogeb river at 1700-2200 m.</td>
<td>KF</td>
<td>EN B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td>Dombeya longibracteolata Seyani</td>
<td>Sterculiaceae</td>
<td>Three localities in Kefa, Gamo Gofa and Sidamo regions are known, where the tree species occurs in Combretum-Terminalia wood and at altitudes of 1900-2000 m.</td>
<td>KF, GG, SD</td>
<td>VU B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td>Echinops ellenbeckii O. Hoffm.</td>
<td>Asteraceae</td>
<td>A shrub that grows in upland grassland, along roadside margins, and in Podocarpus forest at altitudes of 2200-3000 m.</td>
<td>SU, AR, HA</td>
<td>EN A2cd + B2ab(i, ii, iii)</td>
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<tr>
<td><em>Erythrina baurii</em> Chiov.</td>
<td>Leguminosae</td>
<td></td>
<td>HA, BA</td>
<td></td>
</tr>
<tr>
<td><em>Erythrostachys uniflora</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td></td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td><em>Erythrina senegalensis</em> Verdc.</td>
<td>Sapindaceae</td>
<td></td>
<td>HA</td>
<td></td>
</tr>
<tr>
<td><em>Euphorbia beltheri</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td></td>
<td>BA</td>
<td></td>
</tr>
<tr>
<td><em>Euphorbia betuloloba</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td></td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td><em>Euphorbia burgii</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td></td>
<td>HA</td>
<td></td>
</tr>
<tr>
<td><em>Euphorbia daubentoniensis</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td></td>
<td>SD, HA</td>
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A shrub known only from an area of bushland between 1350 m and 2100 m in Hararghe, the species is relatively restricted in distribution but fast growing and under no present threat. Cultivated specimens are found elsewhere in Ethiopia.

A shrub of *Acacia Commiphora* bushland growing at altitudes of 950-1400 m. It can be found south-east of Hiku on the road to Bogdo Mayo.

A shrub of *Acacia Commiphora* woodland growing at altitudes of 1150-1500 m. It grows at altitudes of 1200-1550 m, it is found south of Midaga, 70 km south of Harar.

A shrub of limestone slopes growing at 1200-1500 m. It is found south of Dalalett, above the Goebell river.
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<tr>
<td><em>Euphorbia doloensis</em> M.Gilbert</td>
<td>Euphorbiaceae</td>
<td>This shrub species is known only from the type collection, in open Commiphora-Boswellia bushland on steep rocky slopes at 400-500 m in Sidamo region.</td>
<td>SD</td>
<td>CR (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Euphorbia ellenbeckii Pax</em></td>
<td>Euphorbiaceae</td>
<td>A shrub of <em>Commiphora</em> woodland growing at 1000-1100 m.</td>
<td>SD</td>
<td>EN B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Euphorbia fissispina</em> Bally &amp; Carter</td>
<td>Euphorbiaceae</td>
<td>A shrub that grows in <em>Acacia-Commiphora</em> woodland at altitudes of 700-800 m near Bogol Mayo in Sidamo region.</td>
<td>SD</td>
<td>EN B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Euphorbia makallensis</em> Carter</td>
<td>Euphorbiaceae</td>
<td>A shrub that grows in a very limited area of rocky limestone habitat at altitudes of 2260-2385 m. It is known only from the type.</td>
<td>TU</td>
<td>CR (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Euphorbia nigrispinooides</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td>A species which is locally common on lava flows growing at 1000-1450 m in open deciduous woodland. It is known from Shewa but its distribution may extend into Hararghe and possibly Somalia.</td>
<td>SU, HA?</td>
<td>VU B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Euphorbia ogadenensis</em> Bally &amp; Carter</td>
<td>Euphorbiaceae</td>
<td>A tree of limestone slopes, growing at altitudes of 300-400 m between Ferfer and Mustahil.</td>
<td>BA, HA</td>
<td>CR (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Euphorbia somalensis</em> Pax</td>
<td>Euphorbiaceae</td>
<td>A shrub known only from a single collection, from Acacia-Commiphora bushland at altitudes of 1100-1200 m.</td>
<td>HA</td>
<td>CR (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
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<tr>
<td><em>Euphorbia uniglans</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td>A shrub known only from the type found west of Wabe Shebele at 600-700m. Montane meadows at altitudes of 1400-1500 m in Sidamo.</td>
<td>BA, CH, CI</td>
<td>GP, m. f. (i, ii, iii, iv) + B1ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Euryops pinifolius</em> A. Rich.</td>
<td>Asteraceae</td>
<td>This species is a shrub that grows in montane meadows at altitudes of 3200-3700 m. It grows with <em>Lobelia</em> on thin soil, on rocks and on cliff margins.</td>
<td>SD</td>
<td>EN B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Ficus ruspelii</em> Warb.</td>
<td>Moraceae</td>
<td>This tree is only known from two collections. It is recorded from deciduous bushland at 1800-1900 m.</td>
<td>SD, KF</td>
<td>VU B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Helichrysum elephantinum</em> Cufod.</td>
<td>Asteraceae</td>
<td>This shrub grows at altitudes of 2470-3320 m in wet <em>Hagenia</em> forest with dense undergrowth.</td>
<td>BA, GG, SD</td>
<td>VU B2ab (i, ii, iii)</td>
</tr>
<tr>
<td><em>Helichrysum horridum</em> (Sch. Bip.) A. Rich.</td>
<td>Asteraceae</td>
<td>This shrub grows in <em>Erica-Lobelia</em> scrub in Afroalpine vegetation at altitudes of 3300-3600 m.</td>
<td>GD, SU</td>
<td>EN B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Hibiscus boranensis</em> Cufod.</td>
<td>Malvaceae</td>
<td>A shrub found in <em>Juniperus-Barbeya</em> and <em>Acacia-Commiphora</em> woodland at 1200-1750 m.</td>
<td>SD</td>
<td>VU B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Hibiscus hochstetteri</em> Cufod.*</td>
<td>Malvaceae</td>
<td>A shrub of upland bushland, growing at 1000-1800 m.</td>
<td>TU, GD</td>
<td>VU B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Hydebrandtia aloysii</em> (Chiov.) Sebsebe</td>
<td>Convolvulaceae</td>
<td>A shrub of <em>Acacia-Commiphora</em> Combretum woodland on rocky limestone slopes, growing at altitudes of 850-1520 m.</td>
<td>HA, BA</td>
<td>VU B1ab (ii, iii, iv)</td>
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<tr>
<td><em>Hildebrandtia diredawaensis</em> Sebsebe</td>
<td>Convolvulaceae</td>
<td>A shrub of Acacia woodland, growing on limestone slopes at altitudes of 1100-1700 m.</td>
<td>HA</td>
<td>EN B1ab (ii, iii, iv)</td>
</tr>
<tr>
<td><em>Hybanthus puberulus</em> M. Gilbert</td>
<td>Violaceae</td>
<td>A shrub of <em>Acacia-Conniphora</em> bushland on limestone at 1300-1650 m. It grows 100 km from Negele on the road to Filtu.</td>
<td>SD</td>
<td>CR</td>
</tr>
<tr>
<td><em>Hypericum gnidiifolium</em> A. Rich</td>
<td>Guttiferae</td>
<td>A bushy tree known only from two disjunct localities beside streams at altitudes of 1900-2700 m, one in Wogera on the Maye-Borhha Plateau in Tigray, and another in Choa in Shewa. It has not been collected recently.</td>
<td>TU, SU</td>
<td>VU A2cd+B2ab (ii, iii, iv)</td>
</tr>
<tr>
<td><em>Indigofera curvirostrata</em> Thulin</td>
<td>Leguminosae</td>
<td>A shrub with a very limited distribution, growing in bushland on rocky limestone slopes at 900-1000 m, 90 km east of Filtu.</td>
<td>SD</td>
<td>CR</td>
</tr>
<tr>
<td><em>Indigofera ellenbeckii</em> Bak. f.</td>
<td>Leguminosae</td>
<td>A species of shrub that is only known from the type.</td>
<td>HA</td>
<td>B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Indigofera kelleri</em> Bak. f.</td>
<td>Leguminosae</td>
<td>A dry bushland shrub known only from the type.</td>
<td>HA</td>
<td>CR</td>
</tr>
<tr>
<td><em>Indigofera rothii</em> Bak.</td>
<td>Leguminosae</td>
<td>A species that reaches the stature of a small tree. It is confined to upland scrub and forest margins in an area where the majority of the Ethiopian population lives at 2100-2800 m.</td>
<td>HA</td>
<td>B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Inula arbuscula</em> Del.</td>
<td>Asteraceae</td>
<td>A shrub that grows in Erica arborea scrub at altitudes of 3200-3600 m.</td>
<td>GD</td>
<td>CR</td>
</tr>
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*Hildebrandtia diredawaensis* Sebsebe

*Hybanthus puberulus* M. Gilbert

*Hypericum gnidiifolium* A. Rich

*Indigofera curvirostrata* Thulin

*Indigofera ellenbeckii* Bak. f.

*Indigofera kelleri* Bak. f.

*Indigofera rothii* Bak.

*Inula arbuscula* Del.
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<tr>
<td><em>Inula confertiflora</em> A. Rich.</td>
<td>Asteraceae</td>
<td>A shrub that grows at 2500-3700 m and is recorded from Juniperus-Podocarpus forest, along stream banks and montane slopes.</td>
<td>WU, SU, HA, BA, AR</td>
<td>NT</td>
</tr>
<tr>
<td><em>Kanahia carlsbergiana</em> D. Field, I. Friis &amp; M.G. Gilbert.</td>
<td>Asclepiadaceae</td>
<td>A shrub that grows along permanent streams at altitudes of 1300-1900 m. It is known from three collections.</td>
<td>AR, BA</td>
<td>EN B1ab (i, iii)</td>
</tr>
<tr>
<td><em>Kirkia burgeri</em> Stannard subsp. burgeri</td>
<td>Simaroubaceae</td>
<td>A tree of dense deciduous bush and limestone slopes at 1100-1400 m.</td>
<td>SD, BA, HA</td>
<td>VU B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Kleina gypsophila</em> J.P. Lebrun &amp; A.L. Stork</td>
<td>Asteraceae</td>
<td>A shrub species that grows on gypsum soils. It has been recorded 84 km north west of Gode.</td>
<td>HA</td>
<td>CR</td>
</tr>
<tr>
<td><em>Kleina negrii</em> Cufod.</td>
<td>Asteraceae</td>
<td>A shrub of <em>Acacia-Commiphora</em> bushland that grows at altitudes of 100-1250 m.</td>
<td>WU, HA, SD</td>
<td>EN B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Kotschya recurvifolia</em> (Taub.) F. White subsp. aetiopica Verdc.</td>
<td>Leguminosae</td>
<td>A shrub that grows on grassy slopes, hillsides and roadsides at altitudes of 1300-2400 m.</td>
<td>BA, HA, KE, SD</td>
<td>VU B1ab (i, iii)</td>
</tr>
<tr>
<td><em>Lantana kisi</em> A. Rich.</td>
<td>Verbenaceae</td>
<td>A shrub recorded only from Ouodgerate.</td>
<td>TU</td>
<td>EN B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Lavandula erythraea</em> (Chiov.) Cufod.*</td>
<td>Lamiaceae</td>
<td>This shrub is only known by the type collected at Mount Lesa.</td>
<td>–</td>
<td>CR A2cd + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Lindenbergia awashensis</em> Hjertson</td>
<td>Scrophulariaceae</td>
<td>A shrub species that grows on lava flows, in <em>Acacia</em> woodland and grassland at 600-1500 m.</td>
<td>AF, SU</td>
<td>EN</td>
</tr>
<tr>
<td><em>Maerua boranensis</em> Chiov.</td>
<td>Capparidaceae</td>
<td>A shrub that grows at altitudes of 750-1400 m in <em>Acacia</em> bushland on calcareous loam and rocky roadsides. Found at Mega, Negelle and Fitlu.</td>
<td>SD</td>
<td>CR</td>
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<tr>
<td><em>Maytenus addat</em> (Loes.) Sebsebe</td>
<td>Celastraceae</td>
<td>A tree of Afrotumante forest, especially along forest margins, and also in secondary formations. It ranges throughout the highlands at altitudes of 2200-3000 m. In the north the expanding human population and agricultural activities have caused a decline in the extent of the forest and continue to put pressure on the remaining habitat. Where the forest is cleared the tree is often left standing because of its usefulness as timber and firewood. The species also has medicinal uses.</td>
<td>SU, AR, SD, GG</td>
<td>NT</td>
</tr>
<tr>
<td><em>Maytenus cortii</em> (Pichi-Serm.) Cuf.</td>
<td>Celastraceae</td>
<td>A shrub that grows on slopes at altitudes of 3500-3600 m in the Simien Mountains.</td>
<td>GD</td>
<td>CR B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Maytenus harenensis</em> Sebsebe</td>
<td>Celastraceae</td>
<td>A small tree endemic to Harena forest, an Afrotumante remnant of forest in the Bale Mountains. It grows at altitudes of 1600-3050 m. The forest is disturbed by logging activities and the building of sawmills in the area has resulted in increased activity.</td>
<td>BA</td>
<td>CR A2c+B1ab (i, iii)</td>
</tr>
<tr>
<td><em>Maytenus parviflora</em> (Vahl) Sebsebe subsp. eritreana (Sebsebe) Sebsebe*</td>
<td>Celastraceae</td>
<td>This species of shrub grows in bushland, often on steep slopes, at altitudes of 1400-2000 m.</td>
<td>Eritrea</td>
<td>EN A2c+B2ab (ii, iv)</td>
</tr>
<tr>
<td><em>Maytenus serrata</em> (A. Rich.) Wilczek*</td>
<td>Celastraceae</td>
<td>A shrub of rocky or grassy slopes growing at 1650-2250 m.</td>
<td>TU, GD, GJ</td>
<td>VU B2ab (ii, iv)</td>
</tr>
<tr>
<td><em>Monadenium shebeliensis</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td>A shrub known only from the type, growing in Acacia-Commiphora bushland at 300-400 m.</td>
<td>HA</td>
<td>CR B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Moringa rivic</em> Chiov. subsp. longisiliquya Verdc.</td>
<td>Moringaceae</td>
<td>A tree of deep rocky gorges and limestone slopes, growing at 1100-1300 m.</td>
<td>SD, BA, HA</td>
<td>VU B2ab (i, ii, iii, iv)</td>
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<tr>
<td><em>Otosigia tomentosa</em> A. Rich.</td>
<td>Lamiaceae</td>
<td>This shrub is restricted to montane bushland in the Simien Mountains, where it grows at altitudes of 2100-3300 m.</td>
<td>GD, WU</td>
<td>VU B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td>subsp. steudneri (Schweinf.) Sebald</td>
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</tr>
<tr>
<td><em>Otosigia tomentosa</em> A. Rich.</td>
<td>Lamiaceae</td>
<td>A shrub of montane bushland, growing at altitudes of 2000-3000 m.</td>
<td>TU</td>
<td>VU B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td>subsp. Tomentosa*</td>
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<tr>
<td><em>Phagnalon quartinianum</em> A.Rich.*</td>
<td>Asteraceae</td>
<td>A shrub of river valleys and montane slopes, growing at altitudes of 1900-2200 m.</td>
<td>TU</td>
<td>EN B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td>M. Gilbert</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td><em>Phyllanthus boreensis</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td>Known only from the type, this shrub species grows in <em>Acacia-Commiphora</em> bushland at 1100-1200 m.</td>
<td>SD</td>
<td>CR B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
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</tr>
<tr>
<td><em>Phyllanthus dewildiorum</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td>A shrub of open woodland at 1400-1800 m.</td>
<td>WG, KF</td>
<td>EN B2ab (i, ii, iii, iv)</td>
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<tr>
<td><em>Phyllanthus limmuensis</em> Cufod.</td>
<td>Euphorbiaceae</td>
<td>This shrub occurs in high rainfall forest, often near streams, at altitudes of 1050-2200 m.</td>
<td>GD, GJ, WG, IL, KF</td>
<td>VU B2ab (i, ii, iii, iv)</td>
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</tr>
<tr>
<td><em>Polyscias farinosa</em> (Del.) Harms</td>
<td>Araliaceae</td>
<td>A tree known as the baboon's chair. It appears to be confined to open woodland on slopes along river systems at altitudes of 1600-2200 m. Although found in an area heavily influenced by agricultural activities and an expanding human population, regeneration is apparently good.</td>
<td>TU, GD, GJ, SU, KF</td>
<td>VU A2cd +B1ab (i, ii, iii, iv)</td>
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</tr>
<tr>
<td><em>Polysphaeria aethiopica</em> Verdc.</td>
<td>Rubiaceae</td>
<td>A shrub of riverine vegetation, often below high water mark, recorded at altitudes of 800-1350 m.</td>
<td>SD, BA</td>
<td>EN A2cd+B2ab (ii, iii, iv)</td>
</tr>
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</tr>
<tr>
<td><em>Pseudolepharisperrum bremeri</em> J.P. Lebrun &amp; A.L. Stork</td>
<td>Asteraceae</td>
<td>A monotypic genus, this shrub grows in open scrub with <em>Boswellia</em>, on gypsum soil 150 km south west of Kelafo.</td>
<td>HA</td>
<td>CR B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
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<tbody>
<tr>
<td><em>Rhus glutinosa</em> A. Rich.</td>
<td>Anacardiaceae</td>
<td>A shrub of forest margins and evergreen scrub, growing at altitudes of 1800-2600 m</td>
<td>TU, GD, GJ</td>
<td>VU&lt;br&gt;A2cd+B1ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td>subsp. <em>Glutinosa</em> *</td>
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</tr>
<tr>
<td><em>Rhynchosia erlangeri</em> Harms</td>
<td>Leguminosae</td>
<td>A shrub of dry scrub, grassy slopes and rocky areas at 1800-2600 m.</td>
<td>HA</td>
<td>EN B1ab (i, iii)</td>
</tr>
<tr>
<td><em>Rhynchosia erythraea</em> Schweinf.*</td>
<td>Leguminosae</td>
<td>A shrub that has a fragmented population. It grows in grassland or bushland at 1000-2000 m on Mt Fantale.</td>
<td>SU</td>
<td>CR&lt;br&gt;B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Rhynchosia splendens</em> Schweinf.</td>
<td>Leguminosae</td>
<td>A shrub of wooded grassland at 1000-1100 m, this species is known only from the type collection at Metema and may be Extinct.</td>
<td>GD</td>
<td>CR&lt;br&gt;A2c + B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Rinorea frisii</em> M. Gilbert</td>
<td>Violaceae</td>
<td>A tree that is found in <em>Aningeria-Celtis</em> forest at 1000-1100 m.</td>
<td>IL, KF</td>
<td>EN A2cd + B2ab (ii, iii, iv)</td>
</tr>
<tr>
<td><em>Rubus aethiopicus</em> R.A. Grah.</td>
<td>Rosaceae</td>
<td>A shrub of <em>Juniperus</em> forest or scrub, on moist ground at 2600-3000 m.</td>
<td>SU, GD</td>
<td>EN A2cd + B2ab (ii, iii, iv)</td>
</tr>
<tr>
<td><em>Rubus erlangeri</em> Engl.</td>
<td>Rosaceae</td>
<td>This species of shrub is only known from two collections. It is recorded from open places in <em>Hyrcicum</em> forest, growing at 3600-3700 m.</td>
<td>BA, SD</td>
<td>EN B2ab (ii, iii, iv)</td>
</tr>
<tr>
<td><em>Ruellia boranica</em> Ensermu</td>
<td>Acanthaceae</td>
<td>This species grows in <em>Acacia-Commiphora</em> woodland on limestone at 1300-1600 m.</td>
<td>SD</td>
<td>EN B1ab (i, iii)</td>
</tr>
<tr>
<td><em>Satureja punctata</em> (Benth.)</td>
<td>Lamiaceae</td>
<td>A shrub of rocky slopes at altitudes of 1600-3700 m.</td>
<td>TU, GD, WU, GJ, SU</td>
<td>NT</td>
</tr>
<tr>
<td>Brij. subsp. <em>ovata</em> (Benth.) Seybold*</td>
<td></td>
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</tr>
<tr>
<td><em>Satureja unguentaria</em> (Schweinf.) Cufod.</td>
<td>Lamiaceae</td>
<td>This shrub grows on slopes at 1500-1650 m.</td>
<td>GD</td>
<td>EN B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Sesbania melanocaulis</em> Bidgood &amp; Friis</td>
<td>Leguminosae</td>
<td>This tree species grows at the edges of montane forest and in evergreen bushland at 1800-1900 m.</td>
<td>KF, WG</td>
<td>EN B1ab (i)</td>
</tr>
</tbody>
</table>

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</thead>
<tbody>
<tr>
<td><em>Sparmannia macrocarpa</em> Ulbr.</td>
<td>Tiliaceae</td>
<td>A shrub of montane forest and scrub-grassland, found at 1800-3000 m.</td>
<td>GD, GJ, WU, SU, AR, WG, KF, GG, HA</td>
<td>NT</td>
</tr>
<tr>
<td><em>Stomatanthes meyeri</em> R.M. King &amp; H. Rob.</td>
<td>Asteraceae</td>
<td>A shrub of montane slopes, growing at 2200-2400 m.</td>
<td>KF</td>
<td>CR B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Tacazzea venosa</em> Decne.</td>
<td>Asclepiadaceae</td>
<td>A shrub that grows on sand and in rocky crevices on the banks of rivers, at altitudes of 800-1500 m.</td>
<td>TU, GD, GJ</td>
<td>EN B1ab (i, iii)</td>
</tr>
<tr>
<td><em>Taverniera abyssinica</em> A. Rich.</td>
<td>Leguminosae</td>
<td>An important medicinal species, this shrub is threatened by collecting. It is sold in the Addis Ababa market as a cure for stomach cramps and fever. It grows on limestone bushland at altitudes of 1700-2300 m.</td>
<td>TU, SU</td>
<td>CR A2cd + B1ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Taverniera schimperi</em> Jaub. &amp; Spach*</td>
<td>Leguminosae</td>
<td>A shrub of bush and woodland growing along the Tekeze river and Blue Nile gorge, at altitudes of 1000-1300 m.</td>
<td>TU, SU</td>
<td>CR A2cd + B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Tephrosia dichroocarpa</em> Steud. ex A. Rich.</td>
<td>Leguminosae</td>
<td>A shrub of rocky places, roadsides and montane forest, growing at 2200-2400 m.</td>
<td>TU, GD, GJ</td>
<td>EN B1ab (i, iii)</td>
</tr>
<tr>
<td><em>Terminalia hararensis</em> Engl. ex Diels</td>
<td>Combretaceae</td>
<td>A taxonomically dubious tree species that may become synonymous with <em>T. polycarpa</em>. It is known only from the type collection in dense bushland in the boundary area between Bale and Hararghe. If found to be a full species, its status would be CR B2ab (ii, iii).</td>
<td>BA, HA</td>
<td>DD</td>
</tr>
<tr>
<td><em>Terminalia hecistocarpa</em> Engl. ex Diels</td>
<td>Combretaceae</td>
<td>As with <em>T. hararensis</em>, this tree species may by synonymous with <em>T. polycarpa</em>. It is known only from the type locality in bushland in Bale. If found to be a full species, its status would be CR B1ab (ii, iii) + B2ab (ii, iii).</td>
<td>BA</td>
<td>DD</td>
</tr>
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</tr>
<tr>
<td><em>Tragia abortiva</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td>Growing in deciduous woodland at 1550-1800 m, this species is locally abundant.</td>
<td>GG</td>
<td>VU B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Tragia negeliensis</em> M. Gilbert</td>
<td>Euphorbiaceae</td>
<td>A shrub that occurs in grassland with <em>Acacia</em> at altitudes of 1300-1600 m.</td>
<td>SD, BA</td>
<td>VU B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Verbasum arbusculum</em> (A. Rich.) Huber-Morath</td>
<td>Scrophulariaceae</td>
<td>This shrub is only known from the type collection. It is recorded from lava flows, <em>Acacia</em> woodland and grassland.</td>
<td>SU</td>
<td>CR B1ab (i, ii, iii) + B2ab (i, ii, iii)</td>
</tr>
<tr>
<td><em>Vernonia cylindrica</em> Sch. Bip. ex Walp.</td>
<td>Asteraceae</td>
<td>A shrub of dry hillsides.</td>
<td>TU, GD, GJ, WG</td>
<td>VU Acd</td>
</tr>
<tr>
<td><em>Vernonia dalettiensis</em> Mesfin</td>
<td>Asteraceae</td>
<td>A shrub that grows in mixed woodland on slopes at altitudes of 1300-1400 m, west of Daletti.</td>
<td>HA</td>
<td>CR B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Vernonia tevoldei</em> Mesfin</td>
<td>Asteraceae</td>
<td>This shrub grows in evergreen montane forest at 1600-2150 m.</td>
<td>KF, BA</td>
<td>EN B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Vernonia thulini</em> Mesfin</td>
<td>Asteraceae</td>
<td>A species of wooded grassland on slopes at 1200-1300 m, known from the Didessa river valley.</td>
<td>WG</td>
<td>CR B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Vigna debanensis</em> Martelli*</td>
<td>Leguminosae</td>
<td>A shrub that grows in grassland and woodland vegetation at 1600-2200 m.</td>
<td>TU</td>
<td>CR A2c + B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Wellsia filluensis</em> D.R. Hunt &amp; J.P. Lebrun</td>
<td>Boraginaceae</td>
<td>This species is known only from the type collection. It is a shrub that grows on thin soil with calcareous outcrops at the crest of Mt Fillu.</td>
<td>SD</td>
<td>CR B1ab (i, ii, iii, iv) + B2ab (i, ii, iii, iv)</td>
</tr>
<tr>
<td><em>Wendlandia arabica</em> Defl. subsp. <em>aethiopica</em> Puff</td>
<td>Rubiaceae</td>
<td>A shrub of rocky slopes, growing at 1400-1500 m.</td>
<td>SU</td>
<td>EN B2ab (i, ii, iii, iv)</td>
</tr>
</tbody>
</table>

* Confined to Ethiopia as well as in Eritrea.
Table 3.2: Least Concern Endemic Species of Trees and Shrubs of Ethiopia. The Ethiopian Provinces in which the Taxa Occur are Given in Abbreviated Form (See Fig. 3.1 on page 34)

<table>
<thead>
<tr>
<th>Name of Plants</th>
<th>Family</th>
<th>Comments</th>
<th>Ethiopian Provinces</th>
<th>Level of Threat (As Per IUCN, 2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Becium ellenbeckii</em> (Gurke) Cufod.</td>
<td>Lamiaceae</td>
<td>A shrub of <em>Acacia-Commiphora</em> bushland, growing on limestone slopes at 1000-1700 m.</td>
<td>SD, HA</td>
<td>LC</td>
</tr>
<tr>
<td><em>Bothriochline schimperi</em> Oliv. &amp; Hiern. ex Benth.</td>
<td>Asteraceae</td>
<td>A shrub of wet montane forests, wooded grassland and stream banks, found at 1300-2800 m.</td>
<td>GD, GJ, SU, WG, KE, IL, GG, AR, BA, SD</td>
<td>LC</td>
</tr>
<tr>
<td><em>Chionothrix latifolia</em> Rendle</td>
<td>Amaranthaceae</td>
<td>This shrub is found at altitudes of 700-1750 m on rocky hillsides in open dry grassland and <em>Acacia-Commiphora</em> scrubland vegetation.</td>
<td>SD, BA, HA</td>
<td>LC</td>
</tr>
<tr>
<td><em>Dombeya aethiopica</em> Gilli</td>
<td>Sterculiaceae</td>
<td>A tree of dry <em>Juniperus</em> forest, forest margins and secondary forest. It is found in various localities in the west and south-west highlands.</td>
<td>GJ, SU, KE, GG, SD 1700-2200 m</td>
<td>LC</td>
</tr>
<tr>
<td><em>Echinops longisetus</em> A. Rich.</td>
<td>Asteraceae</td>
<td>This shrub species occurs in a variety of habitats (e.g. rocky open woodland, pasture, forest margins, along roadsides) at altitudes of 2000-4000 m.</td>
<td>GD, GJ, WU, SU, WG, AR, HA, BA, KE, GG, SD</td>
<td>LC</td>
</tr>
<tr>
<td><em>Erythrina brucei</em> Schweinf.</td>
<td>Leguminosae</td>
<td>A tree of open places in upland forest vegetation, found at 1200-2900 m.</td>
<td>WU, WG, GJ, SU, BA, HA, IL, KE, GD, GG, SD</td>
<td>LC</td>
</tr>
<tr>
<td><em>Euphorbia dumasii</em> S. Carter</td>
<td>Euphorbiaceae</td>
<td>This shrub grows in disturbed forest margins around villages at altitudes of 2400-3600 m.</td>
<td>SU, AR, KE, SD, BA</td>
<td>LC</td>
</tr>
<tr>
<td><em>Leucas abyssinica</em> (Benth.) Briq.*</td>
<td>Lamiaceae</td>
<td>A shrub of mountain bushland, rocky slopes, high grassland and forest edges, found at 1300-2600 m.</td>
<td>TU, GD, GG, SD, BA</td>
<td>LC</td>
</tr>
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<tbody>
<tr>
<td><em>Lippia adoensis</em> Hochst. ex Walp.*</td>
<td>Verbenaceae</td>
<td>A shrub that is common in disturbed areas and at forest margins, growing at 1900-2450 m.</td>
<td>TU, GJ, SU, AR, HA, KF, GG</td>
<td>LC</td>
</tr>
<tr>
<td><em>Millettia ferruginea</em> (Hochst.) Bak. subsp. darassana (Cuf.) Gillett</td>
<td>Leguminosae</td>
<td>A tree that is found in rainforest, riparian forest and woodland at 1600-2500 m.</td>
<td>WG, SU, HA, BA, IL, KF, SD</td>
<td>LC</td>
</tr>
<tr>
<td><em>Millettia ferruginea</em> (Hochst.) Bak. subsp. ferruginea</td>
<td>Leguminosae</td>
<td>A tree of upland forest, riparian forest and coffee plantations, growing at altitudes of 1000-2500 m.</td>
<td>TU, GD, GJ, SU, WG, HA, IL</td>
<td>LC</td>
</tr>
<tr>
<td><em>Rhus glutinosa</em> A. Rich. subsp. neoglutinosa (M. Gilbert) M. Gilbert</td>
<td>Anacardiaceae</td>
<td>A shrub species of forest margins and open bushland on rocky slopes, growing at altitudes of 1800-3000 m.</td>
<td>TU, WU, SU, WG, AR, BA, HA</td>
<td>LC</td>
</tr>
<tr>
<td><em>Senecio myrioccephalus</em> Sch. Bip. ex A. Rich.</td>
<td>Asteraceae</td>
<td>Growing in forest margins at altitudes of 2250-3200 m, this shrub is associated with <em>Hagenia, Erica</em> and <em>Podocarpus</em>. It is used as a hedge plant.</td>
<td>TU, GD, WU, SU, KF, HA, BA, SD, AR</td>
<td>LC</td>
</tr>
<tr>
<td><em>Solanecio gigas</em> (Vatke) C. Jeffrey</td>
<td>Asteraceae</td>
<td>A shrub that grows in montane forest clearings and on river banks at altitudes of 1750-3350 m. It is grown as a hedge plant.</td>
<td>GD, GJ, WU, SU, BA, KF, IL</td>
<td>LC</td>
</tr>
<tr>
<td><em>Tinnea somalensis</em> Gurke ex Chiov.</td>
<td>Lamiaceae</td>
<td>A shrub of open woodland and wooded grassland on calcareous soils, growing at altitudes of 1100-1900 m.</td>
<td>AR, BA, SD</td>
<td>LC</td>
</tr>
<tr>
<td><em>Vepris dainelli</em> (Pichi-Serm.) Kokwaro</td>
<td>Rutaceae</td>
<td>This species is an understorey tree of moist montane forest, growing with <em>Podocarpus</em> or <em>Aningera</em> at 1000-2500 m.</td>
<td>GJ, SU, WG, IL, KF, SD, BA</td>
<td>LC</td>
</tr>
<tr>
<td><em>Vernonia pilgera</em> Oliv. &amp; Hiern.</td>
<td>Asteraceae</td>
<td>A shrub recorded from wooded grassland, seepage area, and rocky slopes near lakes at 1900-2850 m.</td>
<td>TU, GD, SU, KF, SD</td>
<td>LC</td>
</tr>
<tr>
<td></td>
<td>Veronia (Sch. Bip. ex Walp.)</td>
<td>Asteraceae</td>
<td>Veronia (Sch. Bip. ex Walp.)</td>
<td>Asteraceae</td>
</tr>
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<tr>
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<td><em>Veronia kemoli</em></td>
<td>This shrub is recorded from roadside thickets and forest margins at 1850-2850 m.</td>
<td>A species that grows at forest margins and in grassland on open montane slopes at 2150-3000 m.</td>
<td>LC</td>
</tr>
<tr>
<td></td>
<td><em>V. montefii</em></td>
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<td>IC</td>
</tr>
</tbody>
</table>

* Confined to Ethiopia as well as in Eritrea.
Fig. 3.2: Few threatened and near threatened endemic species of trees and shrubs of Ethiopia
Microbial Diversity

Microbial diversity will lead to the discovery of new species and novel metabolic pathways, which may be important from both a basic and an applied science. A total of 44 species of viruses, 61 genera and 89 species of bacteria, 97 genera and 248 species of algae, 35 genera and 45 species of fungi, 8 genera of protozoa and 20 species have been reported as information gathered from different sources (Zekele et al., 2003, Anonymous, 2005).

THREATS TO BIODIVERSITY

Loss of biodiversity is a worldwide concern—one primary cause is habitat destruction and fragmentation (Tilman et al., 2001). In addition to this, the rate of extinctions might be accelerated due to other causes such as invasion by alien species, overexploitation, climate change, habitat deterioration and extinction cascades (Diamond 1989; Thomas et al., 2004;
Fig. 3.4: Few Critically Endangered and Endangered Wild Animals of Ethiopia
Brook et al., 2008; Dunn et al., 2009, Fig. 3.5). The continued growth of human populations and of per capita consumption have resulted in unsustainable exploitation of Earth’s biological diversity, exacerbated by climate change, ocean acidification, and other anthropogenic environmental impacts (Rands et al., 2010).

**LINK BETWEEN FOOD, ENERGY AND BIODIVERSITY LOSS**

<table>
<thead>
<tr>
<th>Indirect Drivers:</th>
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<tbody>
<tr>
<td>Economic</td>
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<tr>
<td>Demographic</td>
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<td>Socio-political</td>
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<td>Cultural and Religious</td>
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<tr>
<td>Science and Technology</td>
</tr>
</tbody>
</table>

**Fig. 3.5: Indirect and Direct Drivers for Loss of Biodiversity**

Diversity of flowering plants has been documented, and measures have been made for their management. Land degradation is a measure threat to biodiversity. However, a little information is available about diversity of non-flowering plant species (Bryophytes, Pteridophytes and Gymnosperms). With genetic improvement of plant and animals, there is major threat of replacement of local varieties and breeds since they are not in frequent use and hence likely to be lost if necessary conservation efforts are not being made. In aquatic system, flowering plants do not dictate their management, Unsustainable exploitation of resources. Pollution is at high level, habitat loss and degradation, and effect of climate change is high on diversity of aquatic life. Biodiversity of invertebrates is largely unexplored. The current trend is that biodiversity is declining.

About 50 per cent of Ethiopia is mountainous, about 90 per cent of its are arable lands and are occupied by 90 per cent of the human population and 60 per cent of all livestock. In the past, the region has been rich in natural diversity and witnessed a seat for human development, ‘cradle of mankind’ with early hominids some 3-4 million years ago/origin of Homo sapiens some 150,000 years ago. With increase and spread of population all over the highland parts of Ethiopia, which once endowed with rich natural resources, is now facing threat. Mountain tops above 3700 m, and the steepest slopes in the highland escarpments, some natural vegetation patches and a few original wildlife species have been able to surviving that are untouched by human interference.

**CONSERVATIONAL APPROACHES**

The statement of the fact to conserve and sustain desired levels of biodiversity seems simple but difficult to manage. It is a broad, general statement which provides no basis for how to take decision to manage this, because there are so many measures of biodiversity. It has biological roots and as a political issue with as many meanings as it has advocates (Redford and Sanderson, 1992). Biological diversity manifest at three levels: species
diversity, genetic diversity and ecosystem diversity. Various meanings of biological diversity are illustrated in Box 1. (See on page 60) Conservation of biological diversity requires a major effort in conducting surveys and inventories, establishing priority, selecting protected areas, managing resources and managing the effects of management (McNeely, 1995). Practical approaches in *in situ* and *ex situ* conservation are illustrated in Figures 3.6, 3.7 and also see Box 2 on page 61.

*Fig. 3.6: Ex situ Conservation Facility*
Fig. 3.7: In Vitro Conservation Facility
BOX 1: MEASURES OF BIOLOGICAL DIVERSITY

Whittaker (1972) described three terms for measuring biodiversity over spatial scales: alpha, beta, and gamma diversity. Among various estimates for measuring biodiversity, species richness and evenness are two important main facets.

(1) **Species richness**: The total number of given species in a quantified area. This can be measured by counting the number of taxa (distinct groups of organisms) within the ecosystem. Alpha diversity refers to the diversity within a particular area or ecosystem, and is usually expressed by the number of species (i.e., species richness) in that ecosystem.

(2) **Species Evenness**: Evenness is a measure of the relative abundance of the different species making up the richness of an area. As species richness and evenness increase, so diversity increases.

(3) **Ecosystem diversity**: It is the variation in the various measures of alpha diversity in between ecosystems. It is a measure of biodiversity by comparing the species diversity between ecosystems. This involves comparing the number of taxa that are unique to each of the ecosystems. It used to compare two ecosystems or to determine changes over time in a given region. Beta diversity measures the present and changes of species diversity between ecosystem.

(4) **Taxonomic diversity of a region with several ecosystems**: Taxonomic diversity is a measure of total biodiversity of several ecosystems within an entire region. It is the product of a diversity of component ecosystems and the \( \beta \) diversity between component ecosystems.

Though biodiversity concept seems simple in definition: “biodiversity is the sum total of all biotic variation from the level of genes to ecosystems”, it is a challenging to quantify such a broad concept. Genetic variation refers to the variation in the genetic make-up of organisms. This usually refers to the genetic variation within a population or a species. One of the approaches in measuring genetic diversity is based on collecting data based on phenotypic differences between individual and finding estimate of genetic component. However, this is an indirect approach. Recently, measuring biodiversity based on gene map is the most accurate measure of biodiversity.
**BOX 2: PRACTICAL APPROACHES IN CONSERVATION OF BIODIVERSITY**

There has been global concern about the loss of valuable genetic resources which has stimulated many new programs for the conservation of plant genetic resources. Within past decade several conservation strategies were developed mainly in the terms of *in situ* and *ex situ* conservation.

I. *In situ* Conservation: It is primary approach for biodiversity conservation (Article 8 CBD). It refers maintaining plants and animals in their original habitat where they have developed their distinctive properties/adaptation. Protected area-Area dedicated to *in situ* conservation. For example, establishment of National Parks, Sanctuary or Biosphere reserves, where there is no danger of hunters or poachers and most notably in farmers fields (also known as on-farm conservation or on site conservation).

**Protected Areas**

*(a) National Parks:* These are government maintained protected areas or reserves, where biodiversity is protected from any kind of exploitation, i.e., cultivation, grazing, hunting, etc., are not allowed.

*(b) Sanctuaries:* These are the areas where hunting is not allowed but other activities like cultivation, rearing, collection of forest products, etc., are allowed. Biological control cause ecological imbalance, shifting cultivation, hot spots (species rich threatened areas), pollution, global climatic changes, high population, industrial agriculture, economic system and policies that fail to value environment; insufficient knowledge and its applications. However, biological diversity on many small islands is under increasing threat, through such impacts as the introduction of exotic species, development of tourism infrastructures, inadequate waste disposal measures, excessive harvesting of particular biotic groups (e.g., corals), and so on. Generally, island species tend to be much more vulnerable to changes in their environments. Populations tend to be small, localized, highly specialized and they tend not to have developed defense mechanisms against a broad range of potential predators or competitors. Under these circumstances, they can easily be driven to extinction.

*(c) Biosphere reserves:* These are multipurpose protected areas of different representative ecosystems which are meant for conservation of biodiversity or wild-life, traditional life style of tribals and their domesticated animals and also plant resources.

*(Contd…)*
(ii) **Maintenance and multiplication:** One major step in establishing in vitro germplasm collections is induction and multiplication of shoots.

(iii) **With in vitro storage:** This technique includes the medium-term storage using slow growth strategy/or artificial seed production, and long-term storage using cryopreservation.

**Genetic stability and in vitro Conservation:** To avoid the genetic alterations in long tissue cultures storage, the storage of germplasm is done at very low temperatures known as cryopreservation. The temperature used are those of liquid nitrogen (-196 °C) or its vapour phase (-150 °C). At these temperatures, all metabolic activity is suppressed minimizing the risk of genetic alterations and eliminating the requirement for refreshing the culture medium. Cryopreservation technique is based on the removal of all freezable water from tissues by physical or osmotic dehydration, followed by ultra-rapid freezing, resulting in vitrification of intracellular solutes.

To ensure genetic integrity during storage, the stored germplasm should be monitored visually every 1-3 month, depending on the species. In case that any abnormalities are found, the tissue culture plants must be grown for an entire cycle in greenhouse examining any morphological changes. Since the visual examination is not reliable, germplasm that has been kept in collection for more than a year should be assessed by biochemical and/or molecular methods. Molecular (DNA) markers are considered to provide the best measure of genetic variation.

### Biodiversity Data and Information: Need to Catalogue Organisms

We must know the organisms that they exist before we can understand or use those (Raven, 1988). Access to biodiversity data is scanty, and most often not available. Quality biodiversity data can play an important role in monitoring biodiversity, and decision making. Information about inventory and specimen collection would lead to effective management of biodiversity. Biodiversity data include:

- global data;
- conservation area data;
- species data;
- genetic data; and
- biological reference collections.

Species information is considered as the basic unit of documenting and describing biological diversity (Stanton and Lattin, 1989). Genetic resources data are basically a repository of samples of living materials of animals,
Each biosphere reserve has a core zone (where no human activity are allowed), a buffer zone (with limited human activity) and manipulation zone (where human activity is allowed without degradation of ecology).

II. Ex situ Conservation (off site conservation): Preservation, maintenance, and breeding of components of biological diversity outside their natural habitat. Complementary to in-situ conservation (Article 8). Example: Zoos, Aquaria, Hatcheries, Botanical garden, Arboretums, nurseries, seed banks, gene banks. When the extinction of species is eminent, ex situ conservation becomes only option available to conserve the species.

It involves preservation and maintenance of samples of living organisms outside their natural habitat in the form of whole plants, seed, pollen, vegetative propagules, tissue or cell cultures. Among ex situ conservation methods the most common are cultivation in botanic gardens, seed storage, and in vitro cultivation.

The place or institution where different plant materials (genes) are kept or preserved is called a gene bank. In gene bank, storage is done either in the form of seeds or vegetative materials, but best and convenient way is storage of seeds. Storage of dry seeds is done at low temperature (-10 to -20°C), because under these conditions, their metabolic activities are minimum which check their germination. Approximately 90 per cent of all ex situ accessions are stored as seeds.

Field gene banks such as arboreta, plantation and botanical gardens are useful for species that are difficult or impossible to store as seed, including vegetatively propagated crops and tree species. Field gene banks account for approximately 8 per cent of all accessions in ex situ storage.

In vitro Conservation of Plant Germplasm: There are wide ranges of techniques in vitro culture, and those based on slow growth of explants are being used with in vitro conservation of germplasm. The most common steps in vitro conservation are:

(i) Culture initiation: Various explant that can be used for in vitro conservation are: shoot (tip, nodal segments), leaf (lamina segments with ribs, petiole), flower pieces, immature embryos, hypocotyl fragments or cotyledons tips, and may also include calli with somatic embryos/ or embryogenic/ or shoot buds. The most commonly used explant is shoot. Young meristematic and rapidly growing tissue explants in early developmental stage are considered to be most suitable;

(Contd...)
plants, fungi, or micro-organisms, generally in a dormant or other phase which they are not actively growing (Hawksworth, 1995). Genetic resource information are collected mainly to ensure the conservation of genetic diversity in the future, the main purpose of which is to use it for breeding purposes. The collection can also be used as a source material for characterization and evaluation. Thus, it is extremely important to conserve adequate stocks followed by regular monitoring and updating. The collection might include stores of gametes, pollen, seeds, spores, tissue cultures and embryos (Hawksworth, 1995). The storage can be maintained in long-term storage facilities as well as in field gene banks. Plant genetic resource collection include: seed samples, Embryos, tissue, cell suspension, pollens, spores, field gene banks; animal genetic resource: Embryos and semen under cryogenic storage Groups of living animals kept under supervision in an exclusive area; Networks of breeding groups; microbial genetic resource collection: microbial cultures, DNA repository, plasmid, vectors, cell lines etc.

Voucher Specimen: Even Molecular Biologist Need Them

Voucher specimens are useful in taxonomic studies, and allow confirmation of identity of species. It provides a backup against misleading results. It serves as quality control for phylogenetic and population genetic analysis based on specimen. Griffiths and Bates (2002) reported usefulness of voucher specimens allowing the explanation of unusual results when a molecular study on New World vultures was seemingly unable to distinguish between greater (Cathartes melambrotus) and lesser (C. burrovianus) yellow-headed vultures. However, many researchers still fail to deposit vouchers for studies (Agerer et al., 2000; Wheeler, 2003). Dennis (1960) quoted in Agerer et al., 2000) commented that “records that cannot be verified are mere waste paper” (Taylor, 2008). So it biodiversity conservation, there must be some sorts of records to corroborate the claims.

Biotechnological Interventions in Biodiversity Conservation

The real challenge in biodiversity conservation is the identification of components of biodiversity, and their characterization. Biotechnology can be used as effective and accurate tool in biodiversity conservation for acquisition of information. Apart from this, gene transfer methods have been extensively debated issue in biotechnology conservation. In this context, these biotechnological interventions are discussed here which are not subject of debate, and would be extremely useful in identification and characterization of biodiversity.

Molecular Markers and Biodiversity Conservation

Taxonomic Identification

In biodiversity conservation, there is need of identification at species, sub-species and population level. The emergence of DNA-based mark
has changed the practice of species identification techniques (Botstein et al., 1980). With new advances in molecular techniques, these assessment are fairly straightforward and inexpensive and are often the only means of resolving taxonomic issues (Haig, 1998). Properties desirable for ideal DNA markers include highly polymorphic nature, co-dominant inheritance (determination of homozygous and heterozygous states of diploid organisms), frequent occurrence in the genome, selective neutral behavior (the DNA sequences of any organism are neutral to environmental conditions or management practices), easy access (availability), easy and fast assay, high reproducibility, and easy exchange of data between laboratories (Joshi et al., 1999). Sequencing based molecular techniques provide better resolution at intra-genus and above level, while frequency data from markers such as random amplified polymorphic DNA (RAPD), amplified fragment length polymorphism (AFLP) and microsatellites provide the means to classify individuals into nominal genotypic categories and are mostly suitable for intra-species genotypic variation (Robinson, and Harris, 1999). Molecular techniques such as DNA barcoding, random amplified polymorphic DNA (RAPD), amplified fragment length polymorphism (AFLP), microsatellites and single nucleotide polymorphisms (SNP) have been used for biodiversity assessment.

**DNA Barcoding**

DNA barcoding is a tool for rapid identification species based on DNA sequences. DNA barcodes consist of a standardized short sequence of DNA (400-800 bp). A massive on-line digital library of barcodes will serve as a standard to which the DNA barcode sequence of an unidentified sample can be matched. DNA barcoding will allow users to efficiently recognize known species and speed the discovery of species yet to be found in nature. DNA barcoding uses the information of one or a few gene regions to identify all species of life (Kress and Erickson, 2008). DNA barcoding is one step closer to implementation in plants (Lahaye et al. 2008). DNA barcoding enables non-taxonomist to identify a species. Natural resource managers and regulators can monitor the illegal trade of processed products using barcoding. It will provide a better tool to control the movement of species across national borders. It provides basis for global networks for any researcher. Since it has requirement of voucher specimens so would improve the national research infrastructure of specimen collections, molecular biology labs, and biodiversity databases.

**Role of Molecular Markers in Characterization of Accessions**

Information about genetic make-up of accession contributes towards decision making for conservation activities-collection, identification, characterization and value addition. Molecular characterization, in conjunction with (phenotypic traits or geo-referred data), provides reliable information for assessing, among other factors, the amount of genetic diversity (Perera
et al., 2000), the structure of diversity in samples and populations (Shim and
Jorgenesen, 2000, Figliuolo and Perrino, 2004), rates of genetic divergence
among populations (Maestri et al., 2002), and the distribution of diversity in
populations found in different locations (Pererra et al., 2000 Ferguson et al.,
2004). Molecular markers find usefulness in characterization of ex situ
accessions, such as seed banks (Culture Collection and Genebanks).

Classification of Microorganisms

16S rDNA sequencing is a powerful tool and by far the single most
common molecular technique presently used for bacterial species identification
(Abbott, 2002).

DNA Banks

Advancement in biotechnology will enable use of collection in
transformation and cloning. DNA bank conserves the genomic DNA, and it
ensures that collection cannot be readily used to re-create the species using
conventional method. Therefore, institutions are encouraged to establish
repositories of genomic DNA.

NANO-BIOTECHNOLOGY AND BIODIVERSITY CONSERVATION

Nanotechnology is the ability to understand, control and manipulate
matter at the level of individual atoms and molecules. Generally
nanotechnology deals with structures of the size 1-100 nanometers
(www.nano.gov/html/facts/whatIsNano.html), and involves developing
materials or devices within that size. Nanotechnogy is new innovation in
Agriculture. This technology holds the promise of controlled release of
agrochemicals and site targeted delivery of various macromolecules in plants
(Carmen et al., 2003; Scrinis and Lyons, 2007; Nair et al., 2010; Ghormade
et al., 2011).

The requirement agrochemicals by plant is at a very low concentration,
however conventionally usually these chemical are applied to a high
concentration to the plants through spraying/ or broadcasting. Most of the
agrochemicals go as waste. In case of fertilizers, excessive amount of nitrogen
and phosphorus leach into groundwater or run off into waterways. This
nutrient overload causes eutrophication of lakes, reservoirs and ponds,
leading to an explosion of algae which suppress other aquatic plants and
animals. Therefore, excessive use of fertilizer poses environmental problems.
Nanoparticles enables slow release of fertilizers to the plant increasing
efficiency of fertilizer use and reduces wastage of nutrients. Nano-fertilizers
is becoming as alternatives to conventional fertilizers. Nanofertilizer will
eliminate problems due to eutrophication and contamination of drinking
water caused by excessive use of fertilizers. Bioremediation of radioactive
wastes, resulted from nuclear power plants and nuclear weapon production
such as Uranium (a long-lived radionuclide hazardous for both flora and
fauna) have been achieved by using nanoparticles. Cells and S-layer proteins of *Bacillus sphaericus* JG-A12 have special capabilities for the clean-up of uranium contaminated waste waters. The effluent derived from the several processes can be bioremediated by treating with *Candida violaceum* (Durán et al., 2007). Insecticides, herbicides and fungicides are also applied heavily in many developed and developing countries, polluting fresh water with carcinogens and other poisons that affect humans and many forms of wildlife. Pesticides also reduce biodiversity by destroying weeds and insects and hence the food species of birds and other animals. Nanoparticle based pesticides may reduce pollution and the loss of biodiversity. Therefore, nanotechnology has opened up new opportunities to improve nutrient use efficiency and minimize costs of environmental protection. Nanomaterials have been useful in several areas of agriculture, such as the slow/controlled-release of fertilizers for plant nutrition, and pesticides for protection against pests and pathogens; sensitive and accurate detection of plant pathogens, and pollutants; protection and formation of soil structure (Nair et al., 2010; Ghormade et al., 2011).

**CHALLENGES OF BIODIVERSITY IN ETHIOPIA**

Third World Countries have diverse biodiversity. Despite obligations by the International Organization to report biodiversity status, and support Government, Non-Government Organization Agencies in conserving biodiversity and, the loss is not slowing down. There has been continued and steady decline in population of wild species. Some of the challenges in conserving biodiversity of Ethiopia are discussed hereunder:

**Declining Biodiversity**

Despite conservational efforts, the biodiversity of Ethiopia continue to decline due to increased population growth, increased consumption and unsustainable exploitation of nature, drought, land degradation, invasive alien species, and some extent climate change.

**Biopiracy/Bioprospecting**

Bioprospecting or prospecting refers to collection, research and use of biological and/or genetic material for purposes of applying the knowledge derived there from for scientific and/or commercial purposes (Jeffery, 2002). This entails the search for economically valuable genetic and biochemical resources from nature. These resources may be used in food production, pest control, and the development of new drug and for other related biotechnological applications. Bioprospecting can be considered as value addition to biodiversity. With advancement in molecular biology, and availability of sophisticated diagnostic tools for screening, it has become very effective for pharmaceutical companies to conduct research through bioprospecting. The doubts have been expressed that through strong R&D
support, pharmaceutical companies would obtain patents on biological and/or genetic material without returning any royalty/compensation to the party from which material/or knowledge has been acquired. TWCs (Third World Countries) are not only rich in biodiversity but also have a very strong cultural history. TK is a community based knowledge system, and sometimes such knowledge is pivotal leading to focusing research into this and deriving commercial benefits. There has been misappropriation of bioprospecting leading to biopiracy. Indigenous knowledge of nature, originating with indigenous people, is exploited for commercial gain without permission from and with no compensation to the indigenous people themselves. Most of the ethnomedical biological information lies in public domain. Therefore, protection of IPR related to TK is a major concern in several countries. National governments have been addressing issues of providing IP protection to under existing IP laws or sui generis mechanism so that intellectual and customary rights of the TK holders are respected, recognized and awarded (Pushpangadan and Nair, 2005).

**Access and Benefit Sharing (ABS)**

Access and Benefit sharing (ABS) has been matter of debate between CBD and Trade Related Intellectual Property Rights (TRIP)S that any application, which seeks an intellectual property protection such as a patent, should also disclose the source of origin of the material and associated knowledge in order to obtain the patent. Although there is some agreement on this issue under the CBD, it is still unresolved under the TRIPS debates on ensuring the disclosure of origin of the material and associated knowledge. Parties to CBD began working on developing a set of internationally agreed principles on ABS which resulted in the adoption of the Bonn Guidelines on ABS in 2002 during the Sixth Conference of Parties (COP) to the CBD. The Bonn guidelines provides the parties and stakeholders with a framework to facilitate access to genetic resources and ensure fair and equitable sharing of benefits through standard practices and procedures of Prior Informed Consent (PIC), Mutually Agreed Terms (MAT) and Material Transfer Agreement (MAT) (Pushpangadan and Nair, 2005).

**Policy Initiatives**

The United Nations prepared the *Convention on Biological Diversity* (CBD) and succeeded in having it adopted in 1992. It entered into force in 1993. A radical change has been brought about by CBD that states have a a sovereign right over biodiversity within their own territory: previously organisms were considered to be the common heritage of mankind. Trade-Related aspects of Intellectual Property Rights (TRIPS) under General Agreement on Tariff and Trade (GATT) of the World Trade Organization (WTO) through Article 27, Patentable Subject Matter. 1. Subject to the provisions of paragraphs 2 and 3, “patents shall be available for any inventions”. It implies members’ country
to provide protection to genetic resources by an effective sui generis system. This in turn necessitates authentic identification and protection to the genetic resource of the country. Ethiopia needs to harmonize international and national laws for biodiversity conservation. Ethiopia is also preparing to ratify the Nagoya Protocol. Keeping in view the importance of the Bioprospecting, it is imperative to prioritize mapping of bioresources, inventorization and assessment of biological diversity, use bioprospecting of molecules and genes for novel product development.

APPENDIX 1

The criteria for Critically Endangered, Endangered and Vulnerable (IUCN, 2001)

Critically Endangered (CR)

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing an extremely high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥90 per cent over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
   (a) direct observation
   (b) an index of abundance appropriate to the taxon
   (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
   (d) actual or potential levels of exploitation
   (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of ≥80 per cent over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

3. A population size reduction of ≥80 per cent, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥80 per cent over any 10 year or three generation
period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 100 km\(^2\), and estimates indicating at least two of a-c:
   (a) Severely fragmented or known to exist at only a single location.
   (b) Continuing decline, observed, inferred or projected, in any of the following:
      (i) extent of occurrence
      (ii) area of occupancy
      (iii) area, extent and/or quality of habitat
      (iv) number of locations or subpopulations
      (v) number of mature individuals.
   (c) Extreme fluctuations in any of the following:
      (i) extent of occurrence
      (ii) area of occupancy
      (iii) number of locations or subpopulations
      (iv) number of mature individuals.

2. Area of occupancy estimated to be less than 10 km\(^2\), and estimates indicating at least two of a-c:
   (a) Severely fragmented or known to exist at only a single location.
   (b) Continuing decline, observed, inferred or projected, in any of the following:
      (i) extent of occurrence
      (ii) area of occupancy
      (iii) area, extent and/or quality of habitat
      (iv) number of locations or subpopulations
      (v) number of mature individuals.
   (c) Extreme fluctuations in any of the following:
      (i) extent of occurrence
      (ii) area of occupancy
      (iii) number of locations or subpopulations
      (iv) number of mature individuals.
C. Population size estimated to number fewer than 250 mature individuals and either:

1. An estimated continuing decline of at least 25 per cent within three years or one generation, whichever is longer, (up to a maximum of 100 years in the future) or

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals and at least one of the following (a-b):
   
   (a) Population structure in the form of one of the following:
       
       (i) no subpopulation estimated to contain more than 50 mature individuals, or
       
       (ii) at least 90 per cent of mature individuals in one subpopulation.
   
   (b) Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 50 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 50 per cent within 10 years or three generations, whichever is the longer (up to a maximum of 100 years).

**Endangered (EN)**

A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a very high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of \( \geq 70 \) per cent over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible and understood and ceased, based on (and specifying) any of the following:
   
   (a) direct observation
   
   (b) an index of abundance appropriate to the taxon
   
   (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
   
   (d) actual or potential levels of exploitation
   
   (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

2. An observed, estimated, inferred or suspected population size reduction of \( \geq 50 \) per cent over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased or may not be understood or may not be reversible, based on (and specifying) any of (a) to (e) under A1.
3. A population size reduction of ≥50 per cent, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥50 per cent over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased or may not be understood or may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) or B2 (area of occupancy) or both:

1. Extent of occurrence estimated to be less than 5000 km², and estimates indicating at least two of a-c:
   (a) Severely fragmented or known to exist at no more than five locations.
   (b) Continuing decline, observed, inferred or projected, in any of the following:
      (i) extent of occurrence
      (ii) area of occupancy
      (iii) area, extent and/or quality of habitat
      (iv) number of locations or subpopulations
      (v) number of mature individuals.
   (c) Extreme fluctuations in any of the following:
      (i) extent of occurrence
      (ii) area of occupancy
      (iii) number of locations or subpopulations
      (iv) number of mature individuals.

2. Area of occupancy estimated to be less than 500 km², and estimates indicating at least two of a-c:
   (a) Severely fragmented or known to exist at no more than five locations.
   (b) Continuing decline, observed, inferred or projected, in any of the following:
      (i) extent of occurrence
      (ii) area of occupancy
      (iii) area, extent and/or quality of habitat
      (iv) number of locations or subpopulations
      (v) number of mature individuals.
(c) Extreme fluctuations in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) number of locations or subpopulations
(iv) number of mature individuals.

C. Population size estimated to number fewer than 2500 mature individuals and either:
1. An estimated continuing decline of at least 20 per cent within five years or two generations, whichever is longer, (up to a maximum of 100 years in the future) or
2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals and at least one of the following (a-b):
   (a) Population structure in the form of one of the following:
      (i) no subpopulation estimated to contain more than 250 mature individuals, or
      (ii) at least 95 per cent of mature individuals in one subpopulation.
   (b) Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 250 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 20 per cent within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).

Vulnerable (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a high risk of extinction in the wild:

A. Reduction in population size based on any of the following:
1. An observed, estimated, inferred or suspected population size reduction of \(\geq 50\) per cent over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are: clearly reversible and understood and ceased, based on (and specifying) any of the following:
   (a) direct observation
   (b) an index of abundance appropriate to the taxon
   (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
   (d) actual or potential levels of exploitation
   (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites
2. An observed, estimated, inferred or suspected population size reduction of ≥30 per cent over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

3. A population size reduction of ≥30 per cent, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥30 per cent over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased or may not be understood or may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) or B2 (area of occupancy) or both:

1. Extent of occurrence estimated to be less than 20,000 km², and estimates indicating at least two of a-c:
   
   (a) Severely fragmented or known to exist at no more than 10 locations.

   (b) Continuing decline, observed, inferred or projected, in any of the following:

   (i) extent of occurrence

   (ii) area of occupancy

   (iii) area, extent and/or quality of habitat

   (iv) number of locations or subpopulations

   (v) number of mature individuals

   (c) Extreme fluctuations in any of the following:

   (i) extent of occurrence

   (ii) area of occupancy

   (iii) number of locations or subpopulations

   (iv) number of mature individuals

2. Area of occupancy estimated to be less than 2000 km², and estimates indicating at least two of a-c:

   (a) Severely fragmented or known to exist at no more than 10 locations.
(b) Continuing decline, observed, inferred or projected, in any of
the following:
   (i) extent of occurrence
   (ii) area of occupancy
   (iii) area, extent and/or quality of habitat
   (iv) number of locations or subpopulations
   (v) number of mature individuals

(c) Extreme fluctuations in any of the following:
   (i) extent of occurrence
   (ii) area of occupancy
   (iii) number of locations or subpopulations
   (iv) number of mature individuals

C. Population size estimated to number fewer than 10,000 mature individuals
   and either:
   1. An estimated continuing decline of at least 10 per cent within 10
      years or three generations, whichever is longer, (up to a maximum
      of 100 years in the future) or
   2. A continuing decline, observed, projected, or inferred, in numbers
      of mature individuals and at least one of the following (a-b):
      (a) Population structure in the form of one of the following:
         (i) no subpopulation estimated to contain more than 1000
             mature individuals, or

      (iii) all mature individuals are in one subpopulation.
      (b) Extreme fluctuations in number of mature individuals.

D. Population very small or restricted in the form of either of the following:
   1. Population size estimated to number fewer than 1000 mature
      individuals
   2. Population with a very restricted area of occupancy (typically less
      than 20 km²) or number of locations (typically five or fewer) such
      that it is prone to the effects of human activities or stochastic events
      within a very short time period in an uncertain future, and is thus
      capable of becoming Critically Endangered or even Extinct in a
      very short time period.

E. Quantitative analysis showing the probability of extinction in the wild
   is at least 10 per cent within 100 years.
APPENDIX 2

List of Biodiversity Resources on Web

- UNEP World Conservation Monitoring Centre: http://www.unep-wcmc.org/
- Convention on Biological Diversity: http://www.biodiv.org/
- IUCN—The World Conservation Union: http://www.iucn.org/
- The IUCN Red List of Threatened Species: http://www.redlist.org/
- Global Biodiversity Information Facility: http://www.gbif.org/
- National Biological Information Infrastructure: http://www.nbii.gov/index.html
- National Biodiversity Network: http://www.nbn.org.uk/
- Nature Serve: http://www.natureserve.org/
- Tree of Life Web Server: http://tolweb.org/tree/
- Conservation International House: http://www.conservation.org/
- World Heritage Centre: http://whc.unesco.org/
- UK Government Sustainable Development: http://www.sustainabledevelopment.gov.uk/
- Biodiversity and Biological Collections WWW Server: http://biodiversity.uno.edu/
- The World Wide Web Virtual Library: http://conbio.net/VL/
- Ecology and Biodiversity

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http://chora.virtualalve.net/biodiversity.htm as access on dated 27 October, 2011
http://etflora.net as access on dated 20 October, 2011
http://www.biodiv.be/ethiopia/ as access on dated 26 October, 2011
http://www.ibc-et.org/ as access on dated 21 October, 2011


www.earthendangered.com/search-regions3.asp?search=1 as access on dated 28 October, 2011
