HAWASSA UNIVERSITY

WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES

TRAINING MANUAL ON:

NON –TIMBER FOREST PRODUCTS IN THE CONTEXT OF SUSTAINABLE FOREST MANAGEMENT AND REDD+

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Acronyms

REDD+	Reduced Emission from Deforestation and Degradation
SFM	Sustainable Forest Management
NTFPs	Non-Timber Forest Products
MAPs	Medicinal and Aromatic Plants
IK	Indigenous Knowledge
WEPs	Wild Edible Plants

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Preamble

This manual is intended to present overviews on the basic concepts in NTFPs, the resource potential in Ethiopia, and thereby appreciate the roles of NTFPs-based forest management for satisfying both development goals and environmental services. It can also serve as an entry point to create a platform and set directions for strengthening collaborations towards ensuring development of NTFPs for SFM and REDD+ projects, with an overall implications to sustainable development. It is also believed that this material can serve as an entry point for further endeavors by providing baseline information highlighting the need to focus on the sector, and bringing it to the attention of development practitioners.

This manual was developed based on two days short-term training offered to participants from MoA and REDD+ focal persons. The Training was held in Wondo Genet, between 26 and 27 November, 2013 with the theme "Integrating NTFPs with SFM and REDD+". Information included in this material are generated mainly through extensive literature review. Besides, users might need to further enrich the knowledge base by searching other related references.

1. Emerging Perspectives on NTFPs

1.1. Introducing the Concept

The forestry sector in general plays a pivotal role in the Ethiopian economy: providing various forest products, export goods diversification, import substitution, employment generation, environmental services, livelihood support, etc. Generally, the benefits and/or goods from forest ecosystems are of two categories: Products (including timber and non-timber) and environmental services. While the products obtained from forest ecosystems are consumptive uses, environmental services are non-consumptive uses of forests. In this context, forest refers to the natural ecosystems in which trees are significant components (often tree crown cover of more than 10% and an area of > 0.5 ha). However, forest products are derived not only from trees, but also from plants, fungi and animals for which the forest ecosystem provides habitat. NTFPs are among the forest products of significant economic importance.

Despite their significant potentials on poverty reduction, livelihoods improvements and environmental sustainability, NTFPs have proved to be difficult to clearly define amongst forest experts, conservationists, development practitioners. This is because of the blurred boundaries between timber and non-timber products, and the underlying difficulty in defining a forest and the evolving nature of the concept and the potential to bring together a diverse set of interests and experiences to the idea of integrated forest management (Ahenkan and Boon, 2010). Consequently, the term has generated a lot of controversies since it was coined in the early 1980s by various authors, such as Posey, Peters, de Beer and McDermott (Neumann and Hirsch, 2000; Jean-Laurent and Patrick, 2002; Belcher, 2003).

Little progress has been made to clear the accruing confusions in terminologies and semantics. A range of terminologies has been used interchangeably by various authors and organizations, which, among others, include "non-wood forest products, "minor forest products", "wild products", "natural products", "secondary forest products", and "hidden-harvest (Chandrasekharan, 1995; FAO, 1999; Wunder and Angelsen, 2003; FAO, 2006). The following table summarizes only some of the definitions given to NTFPs.

Table-1: Examples of definitions of NTFPs provided by different authors

Definitions	Citation
The term "Non Timber Forest Products" (NTFPs) encompasses all biological materials other than timber, which are extracted from forests for human use	De Beer and McDermott (1989)
Non-wood forest products include all goods of biological origin, as well as services, derived from forest or any land under similar use, and exclude wood in all its forms:	Chandresekharan (1995)
"all tangible animal and plant products from the forest, other than industrial wood" In 1998, they slightly modified this definition to include "....all tangible animal and plant forest products other than industrial wood, coming from natural forests, including managed secondary forests and enriched forests.	Ros-Tonen et al. (1995, 1998)
Non wood forest products (NWFP) are defined as 'goods of biological origin other than wood derived from forests, other wooded lands and trees outside forests'	FAO (1999)

The term NTFPs, generally, evolved from the term "Minor forest products" because this dismissive epithet does not reflect their multitude economic, social, and religious or conservation significances. It is also believed by many that the term Non-wood Forest products, proposed and used by FAO, is not inclusive enough of what is important in NTFPs (e.g. the inclusion of charcoal, firewood, tools, carvings, i.e., products extracted using simple technologies by people living in or near the forests).

The important elements of the debate over NTFPs depend on the interests and priorities of the proponents, and are usually centered on five main issues:

i. The Nature of the product – inclusion/exclusion of non-industrial timber and other wood products (Jean and Patrick, 2002; Belcher, 2003).
ii. The source of the product – inclusion/exclusion of forest/tree plantations, managed forest, grassland, managed agroforestry systems within agricultural land
iii. The Nature of Production of the Product– gathered only from the wild, or include those that are domesticated (e.g. rubber, mushrooms, snails, oil palm and other industrial tree plantation crops) (Belcher 2003),
iv. The Scale of Production – capital intensive, industrial scale versus small scale mixed systems,
v. The Ownership and Distribution of Benefits (Ros-Tonen 1999; Belcher 2003; Marshall et al. 2005)- the basis that in many countries, rural people have access rights to NTFPs but not to timber; however often the poor do not have access rights to the more valuable NTFPs

The debate also centers on the expected contribution of NTFPs to poverty reduction, health, conservation as well as on their current and potential benefits to the poor communities versus their further impoverishment (FAO, 1995; Peters, 1996).

Generally, it seem more plausible to refer NTFPs as all botanical and other natural products (tangible and physical objects of biological origin) extracted from forest ecosystems other than timber for human use (De beer and Mc Dermott, 1998). Unlike to NWFPs 9which excludes all woody materials such as timber, chips, charcoal, firewood and other small woods used for tools and household equipments), NTFPs are not necessarily non-wood products, but excludes industrial wood. NTFPs are components of the forest system that exist in nature and are generally not cultivated. NTFPs include plants and plant materials used for food, fuel, fodder, medicine, cottage and wrapping materials, biochemical, as well as animals, birds, reptiles and fishes, for food and feather. NTFPs which are harvested from within and on the edges of natural and disturbed forest, may be all or part of a living or dead plant, lichens, fungi, or other forest organisms. NTFPs have economic or consumptive and social (cultural or religious) values.

Unlike timber, NTFPs comprise many product types, the diversity of product types together with differences in socio-economic & cultural settings of communities in which production and exchange take place management of NTFPs is complex. This enquires many issues to discover in designing salient management technique. There are several ways to classify NTFPs: they can be classified into different categories, based on the purpose of use (e.g., as food, fuel, medicine, farm implements, household utensils); level of use (self supporting, commercial); the plant part used (leaf, fruit, stem, roots); sources (plant and animal products) (Jeannette, 2000).

Table 2: Categories of Non-timber forest products (plant and animal origin products)

Plant products		*Animals and animal products*	
Categories	*Description*	*Categories*	*Description*
Food	Vegetal foodstuff and beverages provided by fruits, nuts, seeds, roots	Living animals	Mainly vertebrates such as mammals, birds, reptiles etc.
Fodder	Animal and bee fodder provided by leaves, fruits etc.	Honey,beeswax	Products provided by bees.
Medicines	Medicinal plants (e.g.leaves, bark, roots) used in traditional medicine and/or by pharmaceutical companies	Bushmeat	Meat provided by vertebrates, mainly mammals
Perfumes and cosmetics	Aromatic plants providing essential (volatile) oils and other products used for cosmetic purposes	Other edible animal products	Mainly edible in vertebrates such as insects (e.g. caterpillars), crabs and other "secondary" products of animals (e.g. eggs, nests)
Dying and tanning	Plant material (mainly barkand leaves) providing tannins and other plant parts (especially leaves and fruits) used as colorants	Hides, skins	Hide and skin of animals used for various purposes
Utensils, handicrafts	Heterogeneous group of products including thatch, bamboo, rattan, wrapping leaves, fibres (e.g. Arouma, Bwa Flo, Silk cotton floss, Screw pine)	Medicine	Entire animals or parts of animals such as various organs used for medicinal purposes (e.g. caterpillars, crab legs, snake oil)
Construction materials	thatch, bamboo, fibres,		
Ornamentals	Entire plants (e.g. orchids, ferns, philodendron) andparts of the plants (e.g. potsmade from roots) used forornamental purposes	Colorants	Entire animals or parts of animals such as various organs used as colorants
Exudates	Substances such as gums(water soluble), resins (water insoluble) and latex (milky or clear juice), released from plants by exudation	Other nonedible animal products	e.g. bones used as tools

Source: (Adapted from FAO, 1995; Shiva and Verma, 2002)

1.2. The Upsurge of interest in NTFPs: development theories

Traditionally, prior to the period 1970s, development concepts (related to forestry) emphasized on large scale plantations meant for timber production. Such development concepts have had their own undesirable consequences: the poor were not the real beneficiaries of investment on timber production, and were associated with severe environmental destruction due to clear cutting of timber. Nevertheless, such development concepts have been changed after the 1970s; emphasis was given to sustainable development through the satisfaction of basic needs of the local forest dependent people.

As a result, over the past two decades, other forest products and services are getting consideration in forestry accounting. In this regard, the collection of NTFPs has been given great emphasis and lots of studies have been made on its various issues. NTFP-based development was, therefore, born as a new development paradigm (Choudhury 2007). The new direction, thus, started to recognize the regulatory role of tropical forest ecosystem on world climate; look for ways that maintain the existence of forest ecosystems & their role; the existence of people who are fully or partly dependent on forest products for their livelihood; for subsistence, for natural remedies, source of cash income, and as raw material for home based industries.

The past decade has witnessed a general spread and upsurge in global interest in NTFPs (Arnold and Ruiz Pérez, 1998; Wollenberg and Ingles, 1998; Neumann and Hirsch, 2000; Marshall et al., 2003). Generally, interest in NTFPs emanates from two view points, which were once assumed win-win:

1) The importance of NTFP for rural livelihood and thus poverty alleviation; and
2) The compatibility of NTFPs extraction/production in tropical forest conservation.

Since then, the importance of NTFPs has moved to the center stage of the global development agenda. The Food and Agriculture Organization (FAO) of the United Nations was one of the first agencies to promote NTFPs through their programme on non-wood forest products. Over the past 20 years, other international agencies such as the World Bank, Canadian International Development Agency (CIDA), International Development Research Centre (IDRC), Center for International Forestry Research (CIFOR), International Union for the Conservation of Nature (IUCN) and the Biodiversity Support Programme (BSP), among others, have incorporated the concept of NTFPs into their research and development programmes. This all depicts the growing momentum on the importance of NTFPs for sustainable development.

1.3. NTFPs in development and conservation circles: Impetus for conservation and livelihood support

As revealed by various reports elsewhere, a much heightened interest of NTFPs emanated on the development and conservation circles. There are a number of reasons for the general spread and upsurge in global interest in NTFPs, especially since the 1980s.

- The demand for many NTFPs is growing fast (e.g. medicinal plants); whereas their habitats and populations are increasingly threatened.
- Economically viable NTFP harvesting may be less detrimental for forest cover and biodiversity than timber harvesting.

- Sustainable incomes from NTFP harvesting and commercialization can provide sufficient incentives for forest and other natural habitat conservation.
- The contribution of NTFPs to the livelihoods of the poor is often high.
- Sustainable NTFP harvesting and commercialization can contribute to poverty alleviation and sustainable livelihoods for people living in and around forests.

Thus, it is believed that the promotion of sustainable use of NTFPs could lead to a win-win situation for poverty reduction and bio-diversity conservation (FAO, 1995; Shiva and Verma, 2002; Golam et al., 2008). This is due to the increasing recognition that NTFPs can contribute significantly to the livelihoods of forest dependent communities (Clendon, 2001; Belcher et al., 2005; Marshall et al., 2005; Ros-Tonen and Wiersum, 2005; FAO, 2006; Ahenkan and Boon, 2010); household food security and nutrition (FAO, 1995; Falconer, 1997; Clark and Sunderland, 2004; Shacleton and Shackleton, 2004; Ahenkan and Boon, 2008); generate additional employment and income (Peters, 1996; Ros-tonen, 1999; Andel, 2000; Marshall et al., 2003); and offer opportunities for NTFP based enterprises (Shackleton and Shackleton, 2004; Subedi, 2006).

(a) NTFPs as a Conservation Means

There has been strong belief that NTFPs are compatible with conservation of natural forests and their biodiversity as opposed to logging for timber or conversion; i.e., it is less destructive in harvesting; e.g. no felling. However, this depends on the production system; type of NTFPs extracted; quantity produced; demand for it; prices of it; number of collectors, etc. (**NB.** <u>In fact, any harvest, small or big, is destructive: it is only the scale!</u>**).** Specially, NTFPs with high market demand can cause destruction; e.g. coffee, incense production, etc.

The premises behind conservation role of NTFPs is that forests could have a greater long term economic value if they are kept standing. In this regard, what makes NTFPs different from timber and important for conservation strategy is:

a) The assumption that under sustained NTFP harvest. The forest remain standing and more or less biologically intact;

b) Local forest communities will tend towards careful, sustainable management of the forest if they receive direct economic benefits from harvesting its resources;

c) Poverty in local forest communities is both a cause and result of deforestation and environmental degradation. If poverty can be alleviated through the harvesting of forest resources, then deforestation pressure will be reduced. Therefore, NTFPs are important forest goods which are environmentally friendly and help conservation of biodiversity and maintenance of environmental functions.

The following are typical examples depicting the Win-Win scenario of NTFPs:

- Rattan production in SE Asia: Rattan is a climbing palm which requires support and shade. Its cultivation does not need clearing existing forests.
- Natural honey production in Ethiopia: requires trees for Shade, hanging hives and as fodder. The bees also contribute for improved productivity of forest through cross pollination. Honey is highly marketable product.
- Natural gum production in arid areas of Ethiopia: the production of gums and resins, when properly practiced, is non-destructive to the trees and the ecosystem. The trees remain standing to continue providing ecosystem services. It is a development option where sustainable livelihood provision and ecosystem conservation can be successfully married. Gums and resin bearing species are adapted to extreme aridity, which makes them better options for dryland conservation and to combat desertification.
- Traditional medication in Ethiopia: inquire maintenance of several species

(b) NTFPs for Livelihoods

NTFPs are generally more extensively used to supplement household income during particular seasons in the year and to help meet dietary shortfalls. In rural areas, many agricultural communities suffer from seasonal food shortages. During these periods the consumption of forest and tree foods tends to increase. However, income from NTFPs is not evenly distributed among all community groups, and different geographic regions. So, income distribution among various groups needs to be understood in order to ensure equity (fair benefit distribution and participation in the development). The economic role of NTFPs can be categorized into two: (i) The role in household subsistence economy, and (ii) Their role in the cash economy. There are different versions of livelihood contributions; as integral part of rural livelihoods and food security:

- Specialized strategy: commercialized NTFPs with high income provision, e.g. coffee
- Diversification strategy: part of portfolio of income sources but still play consider able income with regular involvement
- Coping strategy: only during hard time – as safety net – quick cash or subsistence during difficulties

However, the issue of poverty alleviation through NTFPs is also contested: it depends on the availability/abundance of the products; on the market and price situation; and on the institutional frameworks (right of access, production technology, value added processing, etc). Often in natural state, NTFPs resources are scattered = production costs is high (time and labor) to be significant contributor. In most cases, when the NTFPs are of significant contributor to livelihoods, forest conditions are modified for increased production: →Natural forest based extraction – gradual modification (Semi-managed system) – AF system –

cultivated system. Generally, even though it seems difficult to confirm the Win-Win scenario of NTFPs (i.e., Extraction can help poverty alleviation but when taken to do so will destroy the forest. Achieving both objectives through NTFPs based forest use has limited potential!), NTFPs, upon proper extraction, are important forest goods which are environmentally friendly and help conservation of biodiversity. Therefore, investing on NTFPs and managing forests for the production of NTFPs will enable to secure the multiple benefits of forest ecosystems and hence ensure sustainability.

- **Importance of NTFPs in Ethiopia: Case studies**
  - NTFPs extraction, which is largely family engagement, is the most important sub-sector with considerable cash provision to households.
  - More than 80% of the Ethiopian population depends on traditional medicine from NTFPs for its health practices.
  - Ethiopia also exports natural honey and bees wax (World's 4^{th} and 10^{th} exporter respectively).
  - Harvesting and cultivation of wild spices is wide spread in many areas of southern Ethiopia. e**.g.** Sheka, Keffa, Bench-Maji, South Omo, Gamo Gofa; In 1999 the total supply of spices from Shekicho-Keficho zone alone to the regional and national markets was about 1,208 metric tons.
  - Ethiopia also has about **2,855,000** ha of woodland that can yield natural gum and resin. In the period 1992-2001, for instance natural gum processing and marketing enterprise has produced about 14,675 tones of different natural gum products. This sector can be among the top employment opportunities in remote part of Ethiopia.
  - In Ethiopia there is also a potential for sustainable supply of about 3 million tones of over dried biomass of bamboo ever year.
  - The study of Andargatchew (2008) show 47% of annual cash income of households in Shedem Peasant Association (PA) in Goba district is derived from bamboo sale.
  - Framers of the PA provide about 17,000 – 23,000 bamboo culms each market day to Goba town to earn cash income (Andargatchew, 2008).
  - Ali (2008) in the same region reports that various NTFPs extracted from vegetation of the region contribute on average to 54% of household total annual income.
  - Goba town alone annual firewood turnover worth US$[*] =887,790, and 70 % of the firewood is supplied by women.
  - In Bench Maji, 52% of annual cash income of households is obtained from NTFPs, while in Sheka it contributes to about 41% of household income (Adilo, 2007).
  - In Gore district 88 % of households collect NTFPs, and generate 23 % of their average annual income of 1,895 Birr (Debela, 2004).
  - NTFPs also contribute a similar figure of 27.4 % to the average annual income of households around Menagesha Forest (Fetene, 2006).
  - The mean annual income from beekeeping among households in Walmara district was between 450 and 3,300 Birr (US$ 47 – 347) or 11.6 and 81.9% of total household income depending on wealth status of the households (Lemessa, 2006).
  - Fuelwood, fodder, honey and construction material productions from Chilimo forests contribute significantly to the livelihoods of households in Dendi district, contributing an average to 39 % of the annual household income (Mamo *et al.*, 2007).

(NB) Rate calculation at the time of reporting was 1 USD ≈9.5 Eth Birr

2. Resource Assessment of NTFPs in Ethiopia: resource base, identification and quantification

2.1. The Resource base: Potential and distribution

Ethiopia is endowed with a wide range of ecological and edaphic factors which has favored the formation of different habitat and vegetation zones. It is estimated that there are between 6,500 and 7,000 species of higher plants in the Ethiopian flora, of which about 12% are endemic (Tewoldeberhan, 1991). Everywhere, these diverse vegetation resources provide a range of NTFPs on which the livelihood of a large segment of its population relies on.

Despite the diversity and multifaceted significances, there is no consistent and reliable information on the forest resource base; estimates hitherto vary considerably. This has been reported as one of the major impediments to planning and implementing sustainable forest management interventions in Ethiopia (EPA, 2008). For example, according to the WBISPP in 2004, the total area of high forest of the country was estimated at 4.07 million ha (about 3.56% of the total area of the country). Woodlands and shrubland types are the other most widespread vegetation resources of the country. An estimated area of 29.24 million ha (about 25.5% of the total land area) is covered by woodlands, and about 26.4 million ha (23.1% of the total area) by shrublands (WBISPP, 2004).

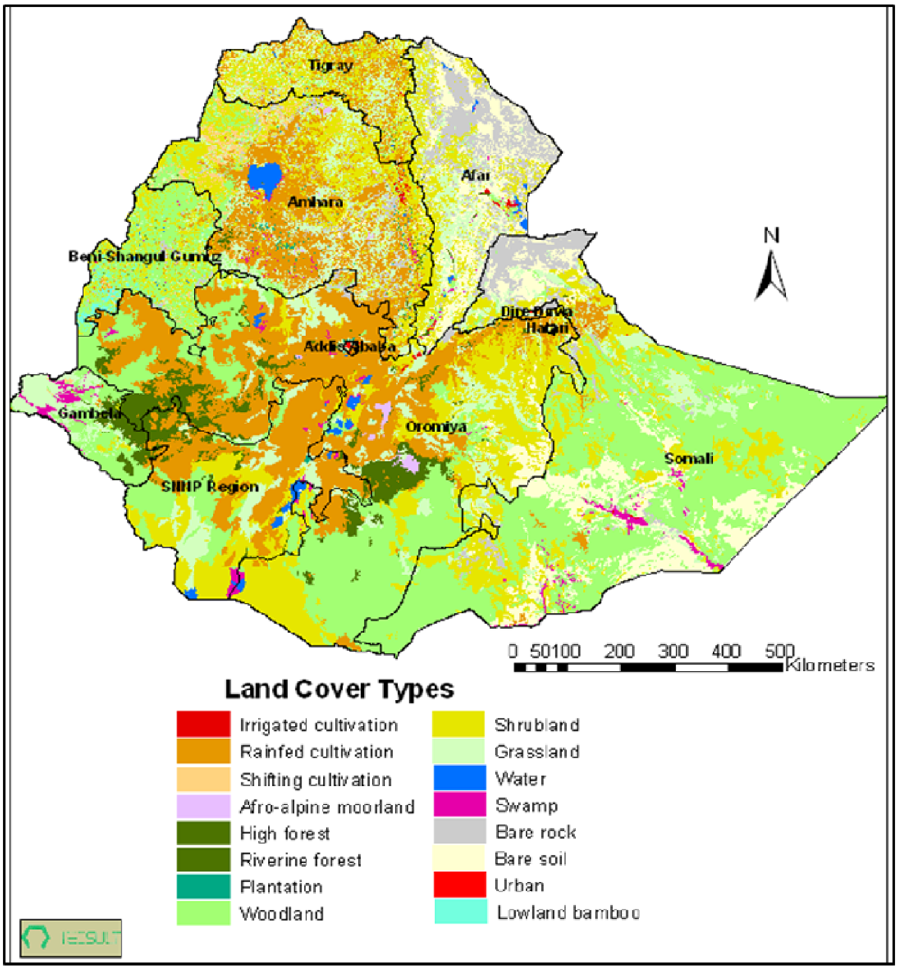

Figure 1: Distribution of the dominant land cover types by region (ha)
(Source: MoARD, 2005)

On the other hand, in Ethiopia, forest resources comprise 5% of high forest (closed and open), 72% of other woodlands, shrublands, savannah and grasslands, 16% of cultivated land, and 7% of others (Earth Trends, 2003).

Table 3: Woodland areas of Ethiopia

Region	**Area (ha)**	**% of total woodland**
Oromiya	9,823,163	34%
SNNR	1,387,759	5%
Gambella	861,126	3%
Amhara	1,040,064	4%
Tigray	254,455	1%
Benishangul-Gumuz	2,473, 064	8%
Afar	163,667	1%
Somali	13,199,662	45%
Total	29,202,960	

(Sources: WBIPP, 2000; unpublished)

The distribution of the vegetation resources in Ethiopia is uneven; with considerable variations in extent and type of vegetation covers within each region in the country. Most of the forest cover of the country is confined in some regions: Oromiya, Benishangul-Gumuz, Gambela, SNNPR and Amhara. According to WBISPP (2004), about 95% of the total high forest is located in three regions namely, Oromiya (63%), SNNPR (19%) and Gambela (13%) regional states. On the other hand, Melessaw and Hilawe (2011) compiled current FAO reports and put the highest woody biomass cover of the country to be distributed in Oromiya, Amhara, Benishangul-Gumuz, SNNPR and Gambela regional states (Figure 1).

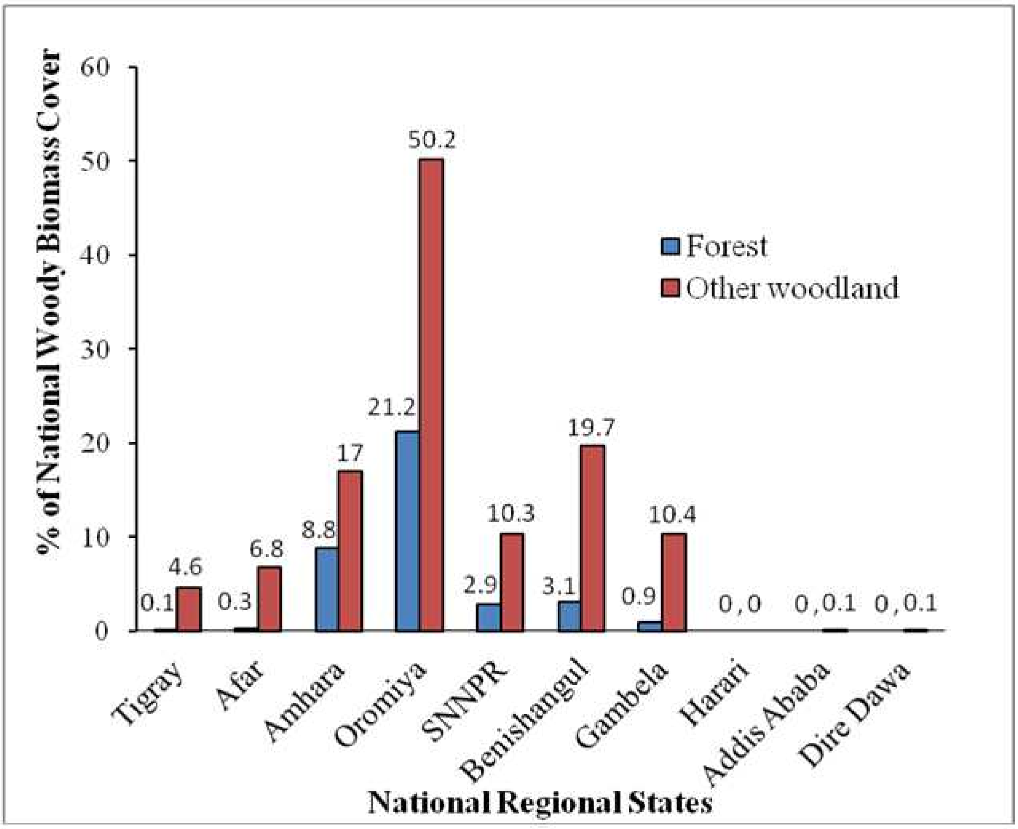

Figure 2: Percentage Distribution of National Woody Biomass Cover by Regions (Ethiopia)

(Source: Adopted from Melessaw & Hilawe (2011))

Dry forests[1], which accounts for 55 – 60% (WBISPP, 2004), are Ethiopia's largest vegetation resources (Mulugeta and Habtemariam, 2011). The Dry forests of Ethiopia are diverse and complex, and comprise vegetations from the very dry Acacia and Commiphora scrublands in the deserts of Afar and Ogaden to forests in the dry sub-humid Afromontane ecosystems in the central highlands. Of the nine broad vegetation types recognized in Ethiopia (Demissiew, 1996; Anonymous, 1997), seven are typical of drylands[2] and can be designated as dry forests: (i) dry evergreen Afromontane forests; (ii) lowland dry forests; (iii) lowland wetland (riparian) vegetations; (iv) evergreen scrubs; (v) *Combretum - Terminalia* (broadleaved) deciduous woodlands; (vi) *Acacia – Commiphora* (small-leaved) deciduous woodlands, and (vii) Desert and semi-desert scrubs. The major attributes of these vegetation types are summarized in Table 2.

Structure and composition of the dry forests of Ethiopia are diverse, reflecting their wide distribution in diverse climatic types and over a large altitudinal range, covering from below sea level in the salt marshes of the Afar depression to the dry cool sub-afroalpine mountains. Structurally, dry forests cover the range from a nearly high forest (closed canopy with tall trees) to desert scrubs. Compositionally, the forests are rich in endemic plant and animal species, especially the lowlands in the south-

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[1] Dry forests is used in a general manner to refer to the different vegetation types found in the drylands of Ethiopia, which comprise all vegetation types (dense and sparse) but the tropical rain forests of southwest and the Afro-alpine and sub-Afroalpine vegetations in the central highlands.

[2] Drylands are areas characterized by seasonal climate having several months of drought (Murphy & Lugo, 1986), or areas with aridity index of ≤ 0.65 (Middleton and Thomas, 1997), and this includes areas traditionally labeled as dry sub-humid, semi-arid and arid.

east. Perhaps one in four Ethiopia's plant species is found only in this part of the country, which is characterized by its high diversity of *Acacia* and *Commiphora* species.

These dry forests are important natural endowments of drylands that have been and are still contributing to human welfare and environmental health. They provide diverse goods and services and thus play considerable ecological and socio-economic roles. They are home for most of NTFPs of economic importance in Ethiopia.

Even though variations exist depending on geographical location, vegetation formation, species type and the degree of disturbances inflicted, the regeneration profile of most species in the dry-forests of Ethiopia are generally poor due to an open-access nature of exploitation. The remnant vegetation resources of the country are receiving severe upheavals from the ever-increasing human-induced and natural stresses (Mulugeta & Habtemariam, 2011); thus they are being depleted at an alarming rate. For instance, according to the 2010 FAO report, Ethiopia lost over 2 million ha of its forests between 1990 and 2005, with an estimated mean annual loss of 140,000 ha. On the other hand, Yigard (2002) put the estimate of the annual forest cover loss of the country between 150,000 and 200,000 ha.

The dry forests of Ethiopia, despite their important socio-economic and ecological benefits, are poorly managed and received no proper silvicultural treatments and attention. They are highly fragmented, poor in regeneration, and degraded in species composition and productivity. Efforts of dryland forest resources restoration are needed for the degraded parts and for conservation and regulated use of the existing forest. Above all, a solution is needed for the open access and unregulated harvest of the dry forest, warranting appropriate institutional arrangements that benefit both the local people and the State. Generally, there is lack of accurate information pertaining to NTFPs in Ethiopia; there is no single responsible body for the collection, documentation, and quantification of NTFPs and their multifaceted contributions either. Despite this paucity of information, the rural people in Ethiopia, which are reservoir of the wild plant lore, have been exploiting the wild plant resources for food, medicine, and other various NTFPs since antiquity (e.g. Amare, 1974; Guinand and Dechassa, 2000; Getachew *et al*., 2005). Thus, collection and use of NTFPs is part and parcel of the livelihood of the rural poor.

Table 4: Vegetation types, distribution, specie composition and state of human disturbance of dry forests in Ethiopia

Vegetation type	Locations/distributions	Major species	Extent of human disturbance
i) Dry evergreen montane forest	• 1900 and up to 3400 m a.s.l., • Central, eastern, south-eastern and northern highlands.	• *Juniperus procera, Afrocarpus falcatus, Prunus africana, Ekebergia capensis, Olea spp. and Apodyttes dimidiate; Allophylus abyssinica, Euphorbia ampliphylla, Olinia rochetiana, Myrsine melanophloeos, Dovyalis abyssinica, Myrsine africana* and *Calpurnia aurea;*	• The most inhabited dry forest zone in Ethiopia, where extensive crop cultivation and grazing is widespread; Forests have significantly diminished.
ii) Lowland dry forest	• 450-600 m a.s.l. This is a special type of forest in Ethiopia, • Only in Gambella region.	• *Acalpha neptunica, Alstonia boonei, Baphia abyssinica, Celtis gomphophylla, C. toka, Milicia excelsa, Mimulopsis solmsii, Xylopia parviflora, Acacia mellifera, Combretum, spp. Terminalia spp.*	• Little affected and the existing threats are mostly for hosting refugees, and due to dams and large scale farming.
iii) low land wetlands (riparian) vegetation	• Along the Rift Valley and Major river courses crossing the lowlands such as the Awash.	• *Celtis africana, Ficus sycamorus, Mimusops kummel, Maytenus senegalensis, Acacia spp., Syzgium guineense, Afrocarpus falcatus.*	• Significantly affected by fuelwood gathering and over grazing.
iv) Evergreen scrubs	• On undulating and steep slopes of the highland plateaus (> 1500 m a.s.l).	• *Euclea schimoeri, Dodonaea angustifolia, Carissa edulis Scolopia theifolia, Rhamnus staddo, Myrsine africana, Alpurnia aurea, Jasminum abyssinicum.*	• Are expanding at the expenses of other forest land degradation.
v) *Combretum – Terminalia* (broad-leaved) deciduous woodlands	• 500 – 1800 m a.s.l., • Western, north-western and parts of south-western lowlands.	• *Boswellia papyrifera, Terminalia glaucescens, Grewia spp. Terospermum kunthianum, Stericulia setigera, Oxytenanthera abyssinica, Balanites aegyptiaca, Annona senegalensis Acacia polyacantha,, A. senegal, A. seyal, Combretum adenogonium, C. collinum* and *C. molle.*	• Human influence is growing in recent years; Fire, crop cultivation (particularly sesame) and over grazing are becoming threats to the vegetation.
vi) A*cacia – Commiphora* (small-leaved) deciduous woodlands	• 900 - 1900 m a.s.l., • Southern, central (Rift Valley) and eastern and south-eastern lowlands.	• *Acacia seyal, A. albida, A. senegal, A. etbaica , A. mellifera, A. drepanolobium, Balanites aegyptiaca, Commiphora africana, C. myrrha, C. fluviflor, C. paolii, C. crenulata, C. guidotti, C. erythraea, C. schimperi, C. ogadensis, C. rostrata, C. serrulata, C. gileadensis, C. hildebrandtii, C. cyclophylla, C. corrugata, Boswellia. microphylla, B. ogadensis, B. neglecta, B. rivae*	• Traditionally occupied by nomadic and agro-pastoralists, • However, those in the Rift Valley are being affected by cropland expansion, grazing, drought and unsustainable fuelwood harvest.
vii) Desert and semi-desert scrubs	• Below 900 m a.s.l., • North-eastern and eastern (Ogaden) lowlands.	• The vegetation consists of deciduous shrubs, mostly *Acacia* spp., together with sparse evergreen shrubs and succulents. *Commiphora* and *Boswellia* species also exist.	• Grazing and refuge camping are affecting the vegetation considerably.

2.2. *A brief account on the major NTFP resources in Ethiopia*

In Ethiopia, NTFPs of significant economic importance include: Natural Gums and incenses; Wild coffee; Bamboo; Herbal medicine; Fuel wood; Small-diameter wood used for poles, posts and carvings; Honey/bee wax; Ecotourism; Spices and condiments; Civet musk; Forest food (Plant & Animal); Forest grazing, etc. These NTFPs have both direct and indirect values.

Table 5: Direct Economic Roles of Major NTFPs in Ethiopia

Product type	**Annual turnover (USD)**
Wild Coffee (25 - 35% of total production or 100,000 - 90,000 tons)	130,590,000
Gum/incense (gum arabic, olibanum, myrrh, etc.)	3,700,000
Honey & bee wax	86,510,000
Herbal medicine	2,055,484,319
Ecotourism (20% of the income from Tourism industry)	15,400,000
Bamboo	10,555,556
Forest grazing (fodder)	-
Forest food	-
Spices (1,208 tons)	2,700,000
Civet (400 tons)	183,000
Total	2,883,000

Source: Mulugeta (2008)

2.2.1. Natural Gums and Resins

In Ethiopia, Dry forests, which comprise the largest forest resources in the country, are known for their varieties of NTFPs, which long played significant roles in subsistence, culture, medicine, food diet and income generation both at local and national scales. Their contribution to rural livelihoods, the national economy and ecosystem stability is significant, although not yet properly accounted for. Of the multitude of NTFPs obtained from the dry vegetations, natural gums and resins are probably the most valuable commodities locally, and nationally: they are the most important export commodities of the Ethiopian forestry sector.

Gums and resins are tapped from a considerable number of trees and shrubs of the genera Acacia, Boswellia and Commiphora, and sometimes from the genus Stericulia. These gum and resin bearing species contribute to improved livelihoods of dryland local communities in terms of food security and income generation, while also contributing considerably to the national economy being among the few export articles that the country owns to earn foreign currency.

The gum-resin bearing species are the leading dominant species in the dryland vegetation resources of Ethiopia. Ethiopia's diversity of plants that yield commercial gums and resins is one of the highest in the world. About 13 species of Acacia, 16 species of Commiphora and 6 species of Boswellia are known as potential yielders of commercial gums and resins in Ethiopia (see Table). Among these, gums from 2 species of Acacia and gum-resins from 3-4 species of Commiphora and 5 species of Boswellia are currently produced commercially. Furthermore, Stericulia setigera, which produces a gum called karaya, is also abundant throughout the country, although gum karaya is not yet under commercial production in Ethiopia.

Table 6: Common and potential gums and resins producing Acacia, Commiphora and Boswellia species found in the drylands of Ethiopia

Acacia	*Commiphora*	*Boswellia*
A. etbaica Schweinf.	*C. africana* (A.Rich.) Engl.	*B. microphylla* Chiov.
A. drepanolobium Harms ex Sjöstedt	*C. boranensis* Vollesen	*B. ogadensis* Vollesen
A. horrida (L.) Willd.	*C. corrugata* Gillett and Vollesen	*B. neglecta* S. Moore
A. mellifera (Vahl.) Benth.	*C. cyclophylla* Chiov	*B. rivae* Engl.
A. oerfota (Forssk.) Schweinf.	*C. gileadensis (L.)* C. Chr.	*B. papyrifera* (Del) Hochst.
A. polyacantha Willd.	*C. guidotti* Chiov.	*B. pirrotae* Chiov.
A. senegal var. senegal Chivo.	*C. habessinica (Berg)* Engl.	*B. sacra* Fluckiger[a]
A. senegal var. kerensis Schweinf		
A. senegal var. leiorhachis Brenan	*C. kua* (R. Br. Ex Royle) Vollesen	
A. seyal var. fistula Schweinf	*C. erythraea* (Ehrenb.) Engl.	
A. seyal var. seyal Hochst. Ex A. Rich	*C. myrrha* (Nees) Engl.	
A. sieberiana DC.	*C. ogadensis* Chiov.	
A. stuhlmannii Taub.	*C. rostrata* Engl.	
	C. schimperi (Berg.) Engl.	
	C. serrulata Engl.	
	C. truncata Engl.	

Source: Lemenih (2005)

[a]This species is reported to exist in Somalia and may not exist in Ogaden area of Ethiopia, although this is yet to be confirmed

Gum- and resin-producing species cover substantial areas of Ethiopia. The country also has vast areas that can be considered potentially suitable for cultivating these tree crops – all the country's arid and semi-arid lands (ASALs), which cover an area of 560 000–615 000 km2. Although estimates differ, because of the lack of a national-scale forest inventory, naturally growing Acacia, Boswellia and Commiphora species are believed to predominate across an area of 28 550–43 350 km2 (Table). Natural gum-producing species occur virtually all over the low-lying zones in the country's west, south, north, east, central (Rift Valley) areas and in the major river gorges such as the Blue Nile, Tekeze, Genale and Wabi Sheblle Rivers. In terms of regional distribution, gum- and resinproducing species are found in the Afar, Amhara, Benishangul-Gumuz, Gambela, Oromia, Somali, Southern Nations and Nationalities and Tigray Regional States.

Table 7: Estimated extent of area containing vegetation with gum- and resin producing species in Ethiopia by regional state

Regional state	Genus	Estimated area (ha)
Afar	*Commiphora, Acacia*	65 000
Amhara	*Boswellia, Commiphora, Acacia, Sterculia*	680 000
Benishangul	*Boswellia, Acacia, Sterculia*	100 000
Gambela	*Commiphora, Acacia, Sterculia*	420 000
Oromia	*Boswellia, Commiphora, Acacia, Sterculia*	430 000
SNNP	*Boswellia, Sterculia, Acacia*	70 000
Somali	*Boswellia, Sterculia, Commiphora, Acacia*	150 000–1 500 000
Tigray	*Boswellia, Sterculia, Commiphora, Acacia*	940 000
Total		**2 855 000–4 355 000**

Source: Fitwi (2000), Lemenih et al. (2003)

Although about 35 species of Acacia, Boswellia and Commiphora have been identified as potential producers of commercial gums and gum resins, currently gums and gum resins are collected from only a few species. Products collected include gum arabic (from Acacia senegal var. senegal, A. senegal var. kerensis, A. seyal var. seyal and A. seyal var. fistula); frankincense (from Boswellia papyrifera, B. neglecta, B. rivae, B. microphylla and B. ogadensis); and Commiphora gum resins (opoponax, myrrh and other myrrh-like gums, mainly from *Commiphora myrrha, C. guidotti* and *C. erythraea*) (see table).

Table 8: Commercial gums and resins with botanical sources and local designations

Category	Common name	Botanical source	Local designation
Aromatic gums/resins		*B. papyrifera*	Tigray type
	Frankincense / Gum olibanum	*B. neglecta*	Borana type[ab]
		B. rivae	
		B. microphylla	Ogaden type[b]
		B. ogadensis[a]	
	True myrrh	*C. myrrha*	Myrrh
	Opoponax	*C. guidotti*	Opoponax
	Hagar	*C. erythraea/ C. africana/others*	Hagar
Non-aromatic gums/ resins (gum arabic)	True Arabic gum	*A. senegal*	
	Gum talha	*A. seyal*	

a Although this species' existence is cited in some references, it remains in doubt (Girmay Fitwi,
personal communication).
b The precise source species for these 2 olibanum classes are not well known. However, gum
resin from Boswellia, true myrrh, opoponax and hagar are collectively referred to as gum myrrh,
whereas products from B. neglecta, B. rivae, B. microphylla and B. ogadensis are often collected
and traded mixed.

Gums and gum resins contribute to local livelihoods, in terms of both cash income, gained by selling products to buyers, and subsistence value. Several gums and gum resins are used as herbal medicines, insecticides and hygienic and sanitation detergents. The annual domestic consumption is expected to grow. Currently, an estimated 10 000 metric tons per annum (estimated value of US$12 million) is consumed locally, 60% of which is used in religious establishments. The exported volume remains much lower than the domestic market, but has been showing an increasing trend since the mid-1990s (Figure 2), due to trade liberalization and involvement of private companies in the export market. Currently, private companies account for about two-thirds of the export volume and earnings. During the 2007/08 fiscal year, Ethiopia exported 4612 tons of gums and resins, to the value of 74 million Birr (about US$7.7 million). The major importing countries in that period were China, United Arab Emirates, Germany, Egypt and Guatemala. China has become the largest importer of frankincense.

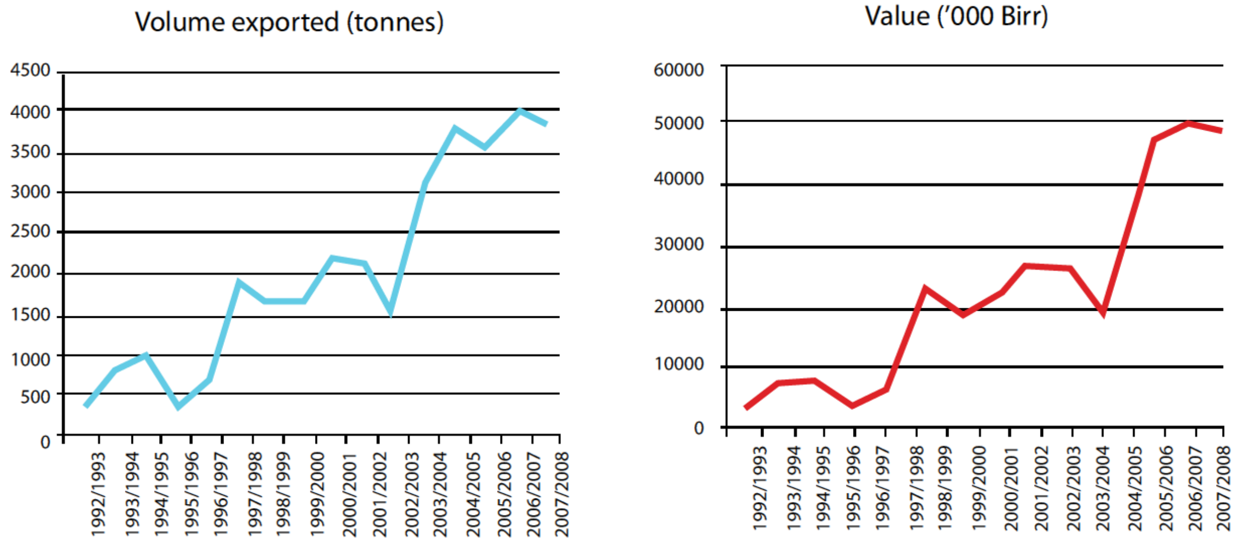


Figure 3: Quantity in tons (left) and value in Birr (right) of gums and resins exports from Ethiopia, 1992- 2008

Source: (Mulugeta and Habtemariam, 2011)

Generally, the gum-resin bearing species are adapted to the drier parts of the country, which are prone to effects of desertification and threats from GCC. Under such a situation, the presence of these vegetation resources offer better adaptation and mitigation options:

- Help to fight against desertification & soil erosion
- Contribute to the conservation or enhancement of biodiversity
- Provide opportunity for C-sequestration and combating CC

2.2.2. Herbal Medicine

The diverse vegetation resources that are found in the various agro-ecological zones of Ethiopia accommodate various types of MAPs: on record there are about 1000 sp (constituting a little over 10% of Ethiopia's vascular flora) are assumed to offer medical value of one or another type; about 52 taxa are endemic (Girma, 1998). Though most still remain traditional medication in Ethiopia, there are a number of patented and commercially manufactured medicines derived from plants that are also native to Ethiopia, and several others also in pipeline. The country is also home to **multi-ethnic cultural diversity,** which have in turn contributed to the high diversity of TK and practices, which among others includes the use of wild plant for medicine.

Table 9: Distribution of the Medicinal Plants in different Ecosystems of Ethiopia

Ecosystem	No. of Sp	%
Acacia-Commiphora woodland	109	12
Montane grassland	93	10.5
Dry evergreen montane forest and evergreen scrubland	83	9.3
Combretum-Terminalia woodland	69	7.8
Moist Montane Forest	48	5.4
Desert and semi-desert scrubland	45	5.1
Afroalpine and sub-afroalpine	44	5.0
Lowland forest	33	3.7
Aquatic	30	3.4
Wetland	23	2.6
Undetermined	300	33.8

Medicinal plants are distributed all over the country, with greater concentration in the south and southwestern part of the country. The woodlands of Ethiopia are the source of most of the medicinal plants, followed by the montane grassland/dry montane forest complex of the plateau. Other important vegetation types for medicinal plants are the evergreen bush land and rocky areas (Girma, 1998; Endashaw, 2007). In Ethiopia, except in few cases where they are cultivated along with home garden crops, most medicinal plants are collected from the wild habitats for both their medicinal values and other non-medicinal uses, such as fuel wood, construction, fodder and fencing (Endashaw, 2007; Tewoldeberhan and Edwards, 2009). This implies that the threats and trends for medicinal plants are similar to those for the forest plant species. Many of these plant species used in traditional systems are becoming rare and limited in distribution; they are being threatened by several factors, both man-made and natural (Girma, 1998).

In Ethiopia, traditional medicinal plants have been used as a source of medicine since antiquity to treat various health problems. It is estimated that about 80% of the rural people in Ethiopia and about 90% of the livestock population rely on traditional medicine to meet their primary healthcare needs (Amare, 1976; Girma, 1998; Endashaw, 2007). The wide spread use of traditional medicine in Ethiopia could be due to cultural acceptability, efficacy against certain types of diseases, physical accessibility and economic affordability as compared to modern medicine (Girma, 1998; Debela *et al*., 2006; Endashaw, 2007).

In Ethiopia, the collection of wild plants for food and medicinal values has been practiced since antiquity (Dawit *et al*., 2001). Due to its long period of practice and existence, collection of various NTFPs from the wild has become an integral part of the culture of Ethiopian people (Guinand and Dechassa, 2000; Debela *et al*., 2006; Fikadu, 2007). A large segment of the Ethiopian people (about 80%) relies on the use of TM to get relief of various ailments (physical and mental health problems) (Amare, 1976; Girma, 1998; Endashaw, 2007).

Although marketing and selling of TM forms part of the general market scene in Ethiopia, most of the available literature in TM does not include any economic analysis of plant medicine for people who practice it for their livelihood. Great potential exists for medicinal plants to contribute to economic development and poverty alleviation in Ethiopia (Girma, 1998). However, with time the IK is gradually worn away partly for reasons attributed to environmental degradation and deforestation, which in turn brought about the loss of some species including medicinal plants (Dessalegn, 2000).

Table 10: Value added to the Economy by Medicinal Plant Trade (estimates for 2005) in ETB

Value added to the economy by medicinal plant trade	**Birr**
Plants traded	316,944,871
Plants used but not marketed	106,125,000
Total plant material traded and used	423,069,871
Healing services provided (by healers) (less the costs of plant material)	1,632,414,448
Total value added to the economy	**2,055,484,319**

Furthermore, research and development, and *in-situ* and *ex-situ* conservation of most of these plant resources is rudimentary. Hence, appropriate management of these resources could contribute to efforts to conserve biodiversity and protect the environment (Endashaw, 2007). A full-scale plan to conserve, develop, and effectively use these resources requires investment commitments by government agencies, the private sector, and international development organizations. However, before such investments and support can be realized, information on the current condition and value of the resources is crucial.

Table 11: Commonly Marketed Medicinal Plants

No	Plant (scientific name)	Vernacular name	Habit	Part used	Medicinal use
1	*Carissa spinarum*	Agam/Hagmssa	Shrub	Roots	Evil eye, epilepsy
2	*Croton macrostachyus*	Bisana/Bakanissa	Tree	Roots	Gonorrhea
3	*Echinops kebericho*	Kebericho/Karabicho	Herb	Rootstock	Abdominal problem
4	*Embelia schimperi*	Enqoqo/Hanqu	Liana/ Shrub	Fruit seeds	Tapeworm
5	*Glinus lotoides*	Metere	Herb	Fruit	Tapeworm
6	*Hagenia abyssinica*	Kosso/Heto	Tree	Flowers	Tapeworm
7	*Hydnora johannis*	Dechmerech	Root parasite	Whole plant	Nightmare Astringent
8	*Jatropa curcas*		Shrub	Fruit	Evil eye, abdominal problem
9	*Olea europea* ssp *cuspidata*	Woira/Ejersa	Tree	Bark	Renal problems/ mouth bleeding
10	*Plumbago zeylanica*	Amera	Herb	Leaves/fruit	Various
11	*Rumex abyssinicus*	Meqmeqo	Herb	Root	Diarrhea
12	*Securidaca longepedunculata*	Itesemenahe	Shrub	Roots/bark/ leaves	Diarrhea/ various
13	*Silene microselen*	Wegert	Herb	Root	Evil eye/ tapeworm
14	***Taverneria abyssinica***	**Dingetegna**	**Shrub**	**Roots/ bark/ leaves**	**Various/ sudden illness**
15	***Thymus schimperi***	**Tosegn**	**Herb**	**Leaves**	**Gonorrhea**
16	*Warburgia ugandensis*	Befti	Tree	Bark	Malaria
17	*Withania somnifera*	Gizawa	Shrub	Root	Various illness/ Evil eye

2.2.3. Wild Food

a) Wild Edible Plants

Wild edible plant species comprise one of the most important components of the diverse vegetation resources in Ethiopia. Out of the total higher plant species recorded (6,000 to 7,000 species), 8 to10% are estimated to be edible (of which 25% are cultivated, 75% are categorized as wild or semi-wild). Majority of these species (i.e. 72%) have their fruits and/or seeds as the edible parts. The remaining ones are the vegetative parts of the plants, i.e., leaves, stems, and tubers/ roots (Zemede and Mesfin, 2001).

On the other hand, a review by Demel and Abeje (2004) on the status of indigenous fruits reported about 370 indigenous food plant species in Ethiopia, most of which are growing in the wild, representing more than 70 different families. Of these, 182 species, representing 40 plant families, were trees/shrubs with edible fruits/seeds. Still many more wild plant species undocumented yet are believed to be edible (Kebu and Fassil, 2006). Except plantation trees, all other components of forest resources provide habitats for indigenous fruit trees in Ethiopia. Generally, forests, wooded grasslands/scrublands, riverine environments and farmlands within vegetation zones of Ethiopia are important habitats of wild edible plants (Demel and Abeje, 2004).

A recent review on WEPs in Ethiopia (Ermias *et al*., 2011) showed that there are about 413 WEPs (wild edible plants), belonging to 224 genera & 77 families (*Fabaceae, Tiliaceae and Capparidaceae*). They are represented by shrubs (31%) and trees (29%). About 56% (233) of sp have edibility reports from more than one community in Ethiopia, which shows that the different cultural groups of the country share relatively similar knowledge on WEPs utilization. An age-old cultural practice of using WEPs brought people to share the knowledge regarding identification, preparation and consumption of similar WEPs. Nevertheless, it was found that studies on WEPs of Ethiopia covered only about 5% of the country's districts.

Compared to domesticated plant food sources, WEPs tend to be overlooked. However, there is substantial evidence that indicates the importance of WEPs in terms of global food basket; in closing food gaps during periods of drought/scarcity, WEPs play an important role in maintaining livelihood security for many people in developing countries. In most parts of Ethiopia, Wild Edibles form integral parts of the feeding habits of many communities. However, consumption of WEPs seems more common and widespread in food insecure areas where a wide range of sp are consumed. E.g. the Konso people in Southern Ethiopia managed to endure three several drought seasons of crop failure b/n 1996 and 1999 by consuming WEPs available in the region. Many WEPs in Ethiopia were reported as emergency, supplementary or seasonal food sources to avert food insecurity in rural communities.

Generally, Wild-food plants are mainly used:

- As a food supplement by different societies
- In some areas, they are the major sources of vitamins,
- The main diet of the day at certain times of the year among some society or as a means of survival during times of drought and famine
- As some sort of enjoyment or recreation by children
- This is common among many societies in Ethiopia, especially, *Mejengir, Dizi, Shaka, kaffa, Manja, Konso*

WEPs are also important sources of energy and micronutrients: preliminary dietary analysis of some WEPs (e.g. *Tamarindus indica* & *Ximenia americana*) confirmed the presence of (CHO)n, Protein, Fat, Ca, P, Mg, Fe, Zn, K, etc.) (Ermias et al., 2011).

Case study: In some montane forests & the Rift Valley

About 61 plant sp were recorded as edible wild plants

- Some families have contributed more edible plant sp, e.g. *Apocyaneae, Rosaceae, Moraceae*
- Edible fruits/seeds tend to be more common in the families dominated by trees
- Edible leafy vegetable tend to be more common in the families with many herbs and shrubs

Parts consumed	No. of species	% of total
Fruits/seeds	47	77
Leaves	13	21
Roots/tubers	5	8

Source: (Zemede and Mesfin, 2001)

For most of the edible plants (fruit trees/shrubs), the edible parts, e.g. fruits/seeds, are still collected from the wild and largely consumed directly by the households. Though wild edible plant products are collected mainly for household consumption, such food items are also taken to markets in both rural and urban areas, in a wide variety of plant products, thereby generating a modest income source for households. Hence, the consumption and marketing of wild edible plants is a necessary part of the strategies adopted by rural people in order to survive in harsh environments and periods (Guinand and Dechassa, 2000; Demel and Abeje, 2004).

However, in developing countries including Ethiopia, wild foods are often considered to be of low status and their consumption is regarded as a source of shame and insult (Tiwari and Rani, 2004). In normal times, only children, youngsters, women and the poorest families regularly collect and consume wild food (Guinand and Dechassa, 2000; Zemede and Mesfin, 2001; Getachew *et al.*, 2005). In addition, strong traditions, beliefs and religious taboos constrain the use and consumption of wild plants. This obstructs people's willingness to domesticate and cultivate wild food plants (Guinand and Dechassa, 2000; Kebu and Fassil, 2006).

Despite their value, WEPs have not been given due attention and are being faced with anthropogenic & environmental threats in a similar way that affect plant diversity as whole

- Loss of species, due to habitat conversion
- Loss of TK about edible sp along sp loss
- Decreased utilization of wild edible plant sp

The degree of loss of species and knowledge differs among different communities, depending on the economic activities of the community. Ethno-botanical information on cultural, socio-economic and nutritional values is limited. Hence, there is still a need for documentation, to assist in the nationwide nutritional analysis & domestication of WEPs effort to combat food insecurity and ensure dietetic diversity. Conservation of these species (both *in-situ* & *ex-situ*) is highly required to maintain and use the species; E.g. by incorporating into Agro-forestry system; by recognizing IK about the plants.

b) Wild Food: Animals

Ethiopia has a huge potential of wild animal resources that can be consumed. The number of fish, mammals and birds are very high. However, due to social, cultural or beliefs only few are consumed. At present, exploitation of wild animals is limited, e.g., very few bird species (< 10) are used as a food-(<1%); few mammals (around

10-15 species)-(<5%); very few amphibians and reptiles, if there is any very. Additionally, little information is available as to how many animal species are used by different societies.

Hunting- is very common among many societies in Ethiopia. However, loss of habitat coupled with the loss of the animals, hunting becoming less popular. Even these days, many societies living in and around woodlands and forests areas exercise hunting mainly for food, ivories and skin.

- Food
  - Most antelopes (e.g. Bushbuck, reedbuck, Kudu, Diker)
  - Some birds (Francolin, Doves)
  - Monkeys, Bush pig
- Ivories and skin
  - Elephant, Bush pig and Warthog, Baboon
  - Rhinoceros, Leopard, Cheat, Colobus monkey

In some society, hunting wild animals is becoming a source of conflict due to the type of wild animal used as a food; E.g. Manja vs Kaffa

The marketability of wild food animals is, constrained by the following factors:

- less common, except ivories and skins
- Production is very low, only for household use
- In some areas, hunters are paying huge money
- in some area, regulated hunting may be enhanced
- At the same time, damaging, because of limited resources

Although, many Parks are established, human-induced threats have never allowed effect conservation of the animals and their habitats. Most wild animals are very much affected, mainly due to: Habitat conversion and over-harvesting, Poaching Unless, urgent action is taken, many animals may be threatened soon. Thus, there is a need to work toward,

- Raising awareness of the society about their values
- Enhance the benefit of people from the resources
- Conservation approaches, like participatory

2.2.4. Wild coffee

Coffee is Ethiopia's major export item, and about 35% of the total production (100,000) comes from the forest. Coffee is naturally a forest tree, occupying the **lower strata** in the **montane rainforests** of Ethiopia. Wild coffee contribution could be enhanced and taken advantage in many ways:

- Through natural certification it can fetch more money.
- Its genetic material can also generate benefit, and new taste, new gene, new version can also be discovered if research is encouraged

2.2.5. Bamboo

Background: Global perspective

Bamboo is a tropical or warm temperate perennial plant (woody grass) belonging to the grass family (Graminaceae; sub- Bambusoideae). There are over 1500 sp in all genera; of which 43 sp in Africa. About 80% of Bamboo forest and species of the world distributed in Asia and Pacific regions; while the lowest diversity is found in Africa where only five sp naturally occur. Within Africa the **greatest potential bamboo richness is in East Africa (Ethiopia, Kenya, Sudan & Uganda).**

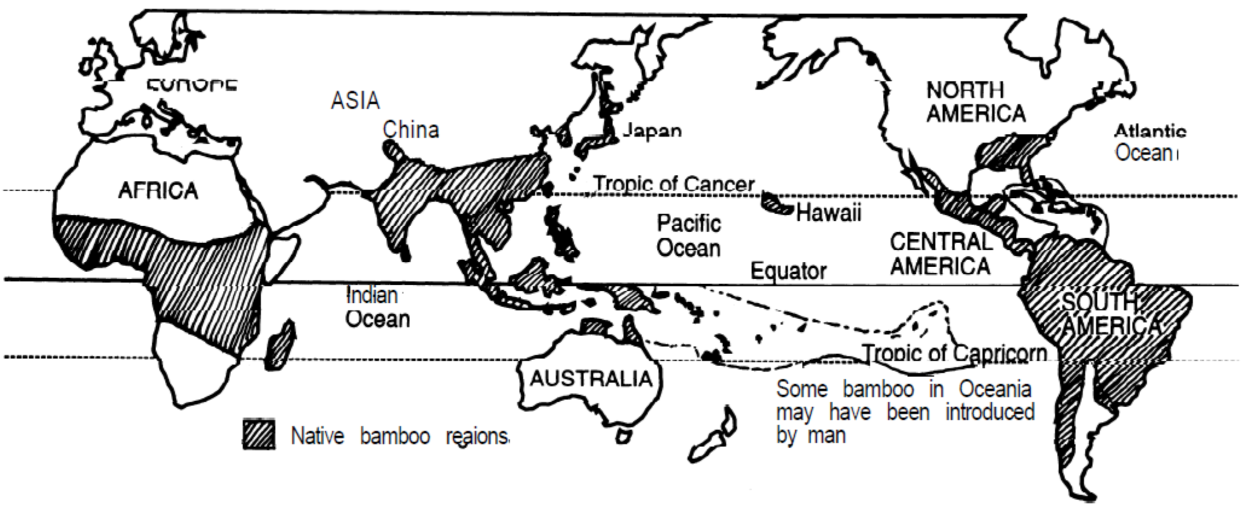


Figure 4: A broad outline of the native bamboo regions in different continents of the world (Morden, 1980).

Bamboo is treated in most literature under NTFPs, although its culms can be put into the same use as timber or poles. Due to the global literature classification of it as NTFPs, we also treated it here in the same way.

- Values of bamboo are being satisfactorily utilized by **tropical Asian countries**.
- There are 25,000 bamboo based industries in India providing employment for about **20 million people** (CIBART, 2004).

- China, which has 4.2 million hectares of bamboo, generates an approximate total of 40 billion birr annually.
    - US$ 130 million from export of **edible bamboo shoots**, 117 million from export of **woven bamboo**
- Bamboo is important raw material for many **pulp and paper industries** in China, India, Thailand and other Asia countries.
- Bamboo provides major uses in the **rayon, handloom, fishing and sericulture industries**, where it supports the livelihood of millions of people,

Generally, Bamboo is a major NTFP (a multipurpose plant) and wood substitute; is a multipurpose plant with a myriad of applications, ranging from construction materials, furniture, fuel, fences, handicrafts, edible shoots, and animal fodder to industrial applications including pulp and paper, functional and decorative uses. Moreover, Bamboo plays crucial role in enhancing Biodiversity and Resilience:

- In its natural state, bamboo thrives as main species in mixed forests,
- Food to large animals, including the bamboo eating giant pandas in China and mountain gorillas and elephants in Central Africa,
- As well as to birds, butter-flies, spiders, and a rich microbial mix in the soil.

Bamboo in Ethiopia

Generally, there is **lack of reliable information** on our bamboo resources; still we are repeating and reporting very old LUSO consult study (LUSO, 1997); which are estimates of four regions. Ethiopia has one of the largest bamboo resources in the World with the estimated area of over 1.1 million ha (150,000 ha of highland and

959,000 ha of lowland); there are two indigenous bamboo species in Ethiopia, which are endemic to Africa:

1) African alpine bamboo (Yushania alpina, previously called Arundinaria alpina) and
2) Oxytenanthera abyssinica; which are endemic to Africa

Ethiopia's natural bamboo forest covers about 7% of the world's total, and 67% of African Bamboo area. It is very important to point out that Ethiopia is the only country in Africa which has over 850, 000 ha of *O. abyssinica* natural bamboo forest (this sp covers about 85% of Ethiopia Bamboo). Bamboo grows with incredible speed and great density per square meter, and its culms mature and is ready for utilization every 3 to 4 years. Though not yet explored, the country should have potential to generate an approximate of 9.5 billion birr annually. Bamboo culms are versatile in application and can be used in numerous industrial and local applications. It would be possible to harvest one third of the total stock every year on sustainable basis (3 million tones of oven dry biomass). This could be used to supply part of the particleboard, fiberboard, pulp, furniture, construction and energy requirement of the nation. Its potential for industrial use has yet to be popularized, as it is presently undertaken in many tropical Asian countries (Embaye, 2000, Luso consult, 1997). The local people and cottage industries use bamboo for different purposes.

- 42 privately owned semi-modern and 16 traditional bamboo entrepreneurs' workshops have been inventoried in Addis Ababa alone (Eastern Africa Bamboo Project, 2007).
- Moreover, two big new bamboo manufacturing companies have recently been established namely the Land and Sea Development–Ethiopia PLC (LSDE) and Adal Industrial PLC, both near Addis Ababa (Eastern Africa Bamboo Project, 2007).

Bamboo has unique morphological characteristics that render it to be used in multitude of applications: every part of it is functional:

- Bamboo for soil and water conservation
- Bamboo for protective function
- Bamboo forest for carbon storage
  - (Bamboo biomass and C production may be 7-30% higher compared with other fast growing woody sp; but is not yet part of CDM
- Bamboo forest for beautifying the environment and tourism
- Other different products
  - Bamboo shoots as food
  - Traditional house construction
  - For furniture uses
  - For Bamboo –based panel boards and pulp/paper Bamboo charcoal, active carbon and bamboo vinegar

2.2.6. Wild honey

Ethiopia's wide climatic and edaphic variability have endowed this country with diverse and unique flowering plants, thus making it highly suitable for sustaining a large number of bee colonies and the long established practice of beekeeping. Beekeeping in Ethiopia is a traditional exercise carried out in all areas: forest beekeeping and backyard beekeeping are common cultural practices of many farmers. Nevertheless, the bees and the plants they depend on, like all renewable natural resources, are constantly under threat from lack of knowledge and appreciation of these endowments.

Ethiopia, having the highest number of bee colonies and surplus honey sources of flora, is the leading producer of honey and beeswax in Africa. On a world level, Ethiopia is **fourth in beeswax and tenth in honey production.** Beekeeping can be practiced virtually all over the country, (showing the vast potential). Beekeeping can make less valuable vegetation resources a more profitable enterprise. Honey and beeswax also play a big role in the cultural and religious life of the people of the country. Beekeeping, like many of the other NTFPs, has the advantage of being **integrated with other land uses** and forests without conflict with any other form of land use therein. Besides honey, there are several products of commerce obtained from apicultural industry. Most important are: - beeswax, propolis, pollen, bee venom and royal jelly. Beeswax is a multipurpose product used in the production of more than 300 commodities. Some of the major ones include:

- Candle making,
- Metal casting and molding,
- Cosmetics,

- Foundation sheet making,
- Food processing,
- For avoiding corrosions and dissolution of iron,
- For insulating circuits of high and ultra high frequency,
- In textiles, varnish and polishes,
- For painting, and
- As a protective surface coating and for pharmaceutical industry.

WIN-WIN scenario of honeybee production:

- Requires trees for Shade, hanging hives and as fodder.
- The bees also contribute for improved productivity of forest through cross pollination.
- Apart from the local consumption, Honey is highly marketable product.

2.2.7. Civet musk: civiculture

Civet musk is a highly praised raw material used in perfumery industry.

- It has Medicinal value, too
- One kg per year, worth 500 USD/kg.
- Ethiopia is the only country in the world with captive breeding; 90% **of world trade**

History and potential of Civiculture

For thousands of years, people have been collecting the musk from male civet to sell and trade in the perfume industry. Ethiopia produces 90% of the world's civet musk, and is the only country in the world where civets are reared in captivity. Niger and Senegal export small quantities of civet musk. In their early history, civet musk was so expensive and valuable that it was used as currency and was valued above gold. The civet musk is sold around the world, but 85% is bought inside of France, the remainder to Japan, North America, Switzerland, Germany, Japan, Hong Kong and the United Kingdom. The musk is also used by humans for medicines, and India imports small quantities for use in its tobacco industry.

One kilogram of musk can produce 3000 litres of good quality perfume (Pugh 1998). With the demand for civet musk growing yearly Ethiopia should be increasing its output as it has the capacity to produce approximately 6000 kg of civet musk annually. Unfortunately only approximately 1000kg is produced and in most cases this musk is classified as impure.

(Yilma, http://www.iucn.org/themes/ssc/susg/docs/adebe.doc.

3. Linking NTFPs with SFM and REDD+

3.1. Sustainable management of NTFP resources

(a) Elements of natural resource management

Natural resource management in general involves an interaction of three major elements. These are the physical resource base: - land water forest, and other tangible natural resources, the production system (mix of technologies and production activities) and, the social regulation (Laws, rules and principles that govern access to resources and their distribution and use).

(b) NTFP management

Sustainable production of NTFPs has several benefits. These include improved food security and better nutrition for the rural people, increased employment opportunities and income in rural areas, availability of a range of products vital for human welfare, increasing participation of people in forest management activities, and enhanced market opportunities. Additionally, processing of NTFPs adds value to the resources by making them suitable for consumption and also supports technology-based development. Importantly, norms for collection, processing and export of high value forest products should be developed. Standards and certification are valuable tools to promote quality at all levels and protect the viability of the NTFPs-based business. Increased of commercial markets for NTFPs might have consequences on ecological processes and ultimately on people's livelihoods. Therefore, sustainable NTFPs entails: wise utilization; strategic manipulation or development of the resource to meet basic need of communities (locals); and enhance critical ecosystem functions.

- Hence, NTFP management comprises: Ecological, Technical, Economic, and Legal and political aspects

(i) Ecological aspect of NTFP management

Although many NTFPs can be harvested successfully in the short term, the long-term sustainability of the NTFP industry depends on a thorough understanding of NTFP biology and ecology for three reasons. First, it is essential to understand how NTFPs grow in order to promote their conservation through sustainable harvesting and cultural techniques. Second, gatherers and entrepreneurs need to understand the biology of NTFPs in order to optimize harvesting operations in both the short and long terms. And third, some NTFPs will eventually require domestication; to achieve this, a complete understanding of their genetics, biology, and ecology will be needed to grow a product that is as attractive as the naturally grown product. This understanding can be acquired through traditional knowledge gleaned from multiple generations of experience, through scientific research, or through a combination of these types of knowledge. So understanding the ecological knowledge of NTFPs are crucial to be used, maintained and monitored the resources wisely.

(ii) **Technical aspect of NTFP management deals with: t**he choice between different methods and techniques, and development of appropriate harvesting and processing technologies.

(iii) **The social aspect of the NTFP management looks in to**: the cultures, belief system, aspirations, and social values, it also deals with competing/conflicting interests of local people.

(iv) **The economic aspect of NTFP management focus on**: maximizing benefits from the resource and increasing resource use efficiency (minimizing input costs and wastes). Furthermore, resource management is also subjected to politics: it involves exercise of power and control over users of resource

(c) NTFP Management Practice Categories

Several categories of management practices could be distinguished for the production and maintenance of NTFP resources

i. Maintenance of the resource through controlled utilization and protection
ii. Stimulation of the production of required products within existing vegetation.
iii. Stimulating regeneration of valued species

Maintenance of the resource through controlled utilization and protection

Activities under the practice:

- Only certain species are harvested according to stand composition. E.g.: size
- Rotational harvesting regimes are employed
- Using harvesting techniques which do not cause tree mortality. E.g.: Limiting harvest level
- Control of pests and disease. E.g.: sanitary pruning.
- Fire control practices.

Stimulation of the production of required products within existing vegetation

Activities under this practice: selecting coppice shoots, rejuvenation pruning, ringing trees to stimulate fruiting; selection of (high yielding) cultivars; decrease water/nutrient/ light competition through weeding and thinning non-desirable species; and optimization of soil conditions. E.g. mulching to favor desired species

Stimulating regeneration of valued species

Activities under this practice: protection of natural regeneration; stimulating of root sprouting; planting of cuttings; transplanting of seedlings and enrichment/ purposeful seeding.

Where to implement what?

- Deciding on the appropriate management practice category for a particular forest type
- From the perspective of scale NTFP management can also be seen in to three levels.
    - Harvest specific practices
    - Management of harvestable and surrounding species, and
    - Management of entire land use system.

a) **Harvest specific practices**

The focus is on:

❖ Specific methods by which the target plant parts are extracted from individual plants. Such as,

- Seasonal timing of harvest
- Timing of harvest in the plant life cycle

- Frequency of harvest
- Size of individuals harvested, and Intensity of harvest

b) **Management of harvestable and surrounding species**

❖ At this scale besides harvest specific practices, the management also involve carrying out activities that enhance the production of surrounding plants and animals

❖ So the management include:
  - Pruning, weeding, fertilizing and planting seeds or vegetative propaguls.
  - Thinning of dense vegetation.

c) **Management of the entire land use system**

❖ At this scale the entire landscape from where the NTFP is harvested is considered in the management.
  - This is with the assumption that population of NTFP species growing in the landscape are subjected to different kind and levels of anthropogenic pressure that may respond to the harvest in different ways.

(d) <u>Sustainability of NTFP Management</u>

- What do you mean Sustainable Forest Management**?**
- When do we say NTFP management is sustainable**?**
- What conditions should be fulfilled, NTFP management to be said sustainable**?**

❖ Sustainable Forest Management is not without a contentious definition, but it is loosely defined as "... to maintain and enhance the long-term health of our forest ecosystems, for the benefit of all living things both nationally and globally, while providing environmental, economic, social and cultural opportunities for the benefit of present and future generations."

- In this context, NTFP management to be called sustainable: – it has to be lucrative over time; yield social improvement for its participants and does not compromise ecological and agronomic equilibrium.
- Sustainability of NTFP extraction is viewed from multiple perspectives: ecological, economic, and socio-political perspective, and at different geographic scales: like local, regional, national and global levels.

Ecological sustainability

The ecological sustainability of the NTFP harvest is a central issue to the long-term availability and management of NTFP on a broad scale. Undoubtedly, the impact of the evolution of harvesting operations from subsistence level use to commercial exploitation will create new pressures on individual species and ecosystems as well as conflicts with other forest users. Indeed, whereas traditional use of NTFPs by First Nations people was restricted by technological limitations, the large-scale use of the NTFPs through modern means of extraction and transportation can have a great impact on individual species and ecosystem productivity.

The ecological sustainability of NTFP harvest can be seen at three levels. These are at the level of individual organism, population level, and ecosystem/community level. At individual or population level, sustainability of harvest requires at a minimum harvest rate do not exceed the capacity of the population to replace the part/individual extracted. How do we check weather sustainability is maintained at population level? A healthy population with the capacity of replacing what is harvested is represented by inversed J-shaped curve (in uneven aged forests). In addition to this, NTFP extraction may also has consequences on community structure and ecosystem functions, For instance, declining density and regeneration of extracted species can lead to substantial changes in structure of forest communities. And shift in the composition of plant community as well as lowering of diversity, biomass and net primary productivity of the ecosystem.

Steps towards ecological sustainability of NTFP harvest

- Complete processes of ecologically sustainable NTFP exploitation comprises six basic operations
    - i. Species selection
    - ii. Forest inventory
    - iii. Yield study
    - iv. Regeneration survey
    - v. Harvest assessment
    - vi. Harvest adjustment

I. Species selection

- Is mainly on economic and social criteria
- In addition the overall potential of the resource to be managed on a sustained-yield bases
    - Some forest species are inherently better able to withstand continuous disturbance by resource extraction than others
- Important ecological factors to be considered during species selection includes: life cycle characteristics of the species (phonology of flowering, fruiting, pollination and seed dispersal); the type of resource produced (its abundance in the forest and, the size class distribution. Density and size class distribution data are the most fundamentals required for the management!

II. Forest inventory

- ❖ Data regarding structure and density of the NTFP species is gathered through quantitative forest inventory.

III. Yield study

- ❖ This is conducted to estimate the total quantity of resource produced by trees of varying size.

IV. Periodic regeneration survey

- ❖ Is used to quantify the initial density of seedlings and saplings in the population being exploited, and to monitor the way in which this density fluctuates in response to differing harvest levels.

V. Harvest assessment

- ❖ This is visual appraisal of the behavior and condition of adult trees
  - Is conducted concurrently with harvest activities.
- ❖ it enables to detect problems with reproduction or growth before it becomes serious enough to reduce seedling production

VI. Harvest adjustment

- ❖ Seedling and sapling density records in the original regeneration survey are used as threshold value by which sustainability is measured
- ❖ As long as density remains above the threshold value and no major problems are detected in the harvest assessment, there is high probability that the current level of exploitation can be sustainable.
  - If density of seedlings and saplings is below the threshold level => harvest adjustment is required

Summary of the Process

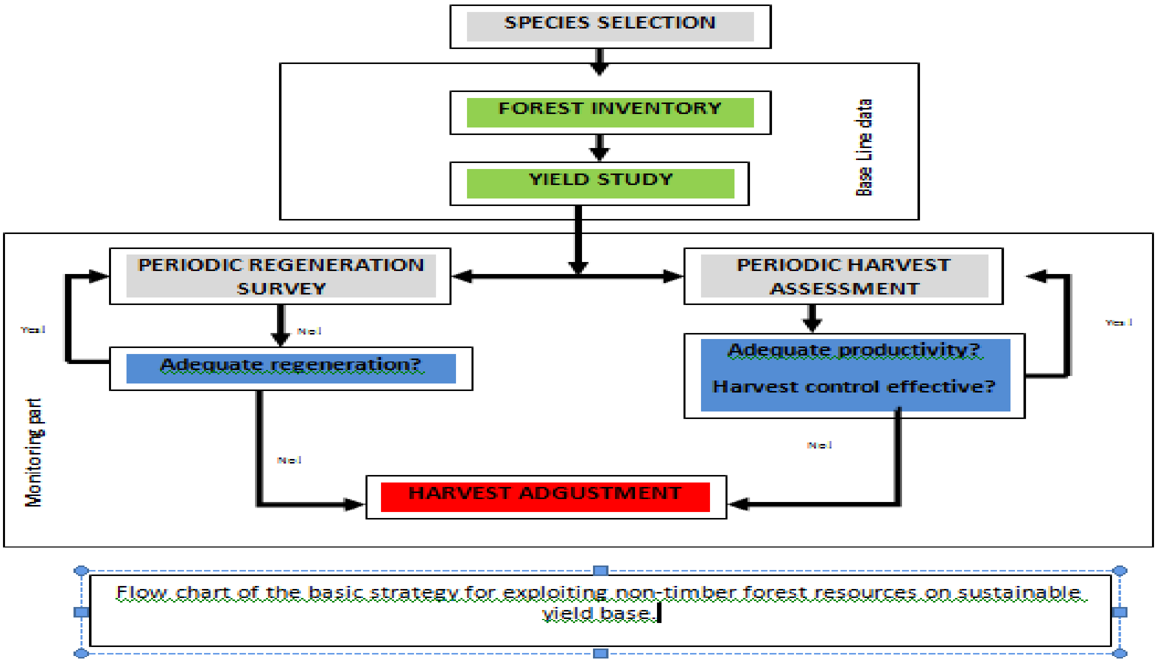


Figure 5: Flow chart of the basic strategy for exploiting non-timber forest resources on sustainable yield base

How to make harvest adjustment?

- Two methods:
  1. Regulate the number and size of the plants being exploited
  2. Limit the total area from which the resource is harvested (Rotational harvest)

Socio-political sustainability

- Resources are managed for the benefits of people.
- So, in the management, the livelihood of forest dependent communities should be emphasized.
- Sustainability can be achieved only when communities using the forest resources recognize the benefits of their conservation efforts.

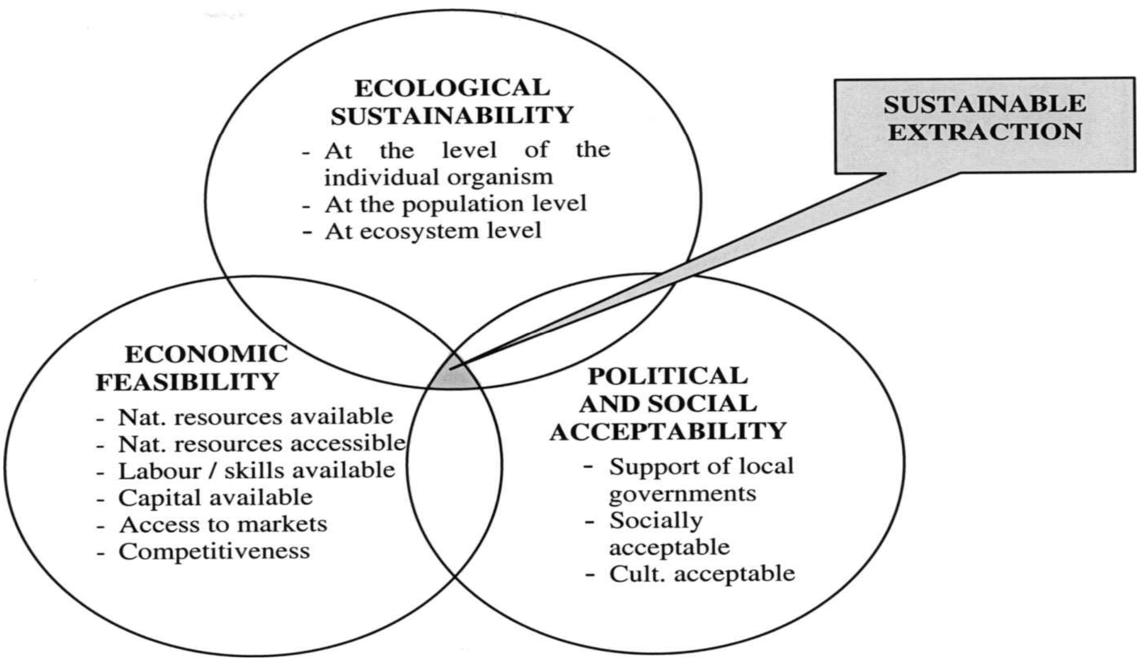
- Local communities should be empowered.
- Local communities should be allowed to control development programs based on their own priority
- Recognized economic & social benefits.
- Strong communication b/n state & forest dependent peoples- balancing national & community interest
- Community organizations should be able to deal with the diverse interests of all the different NTFP users & stakeholders
- Effective mechanisms for conflict resolution exist
- The community has mechanisms for enforcing rules for NTFPs harvesting & management
- There should be equitable bargaining power among individuals or groups/ stakeholders
- So the management strategy should have effective mechanism for settling the different interests & satisfying the interest groups
- Local knowledge should be respected & used in NTFP resource management.
- Sites of special social, cultural, spiritual, & historical significance should be maintained
- The community's land & resource tenure system is guaranteed by the state for the long term

Economic sustainability

Economic sustainability of NTFP extraction is measured in terms of :

- Equitable access to economic decision making
    - ✓ Participation of local interest groups in the management planning & implementation

- Equitable access to economic values
    - ✓ Transparent system of concession allocation
    - ✓ Access to NTFP products to user groups
    - ✓ Employment opportunity for local communities
- Efficient exploitation & processing (in terms of resource utilization)
    - ✓ High use rate of local processing capacity
    - ✓ Low waste ratios in processing
    - ✓ Commercial development of NTFPs
    - ✓ Product diversification
- Economic feasibility (the soundness / profitability of NTFP extraction)
    - ✓ Natural resource availability (quantity & quality)
    - ✓ Accessibility of the resource for use
    - ✓ Labor & skill availability for utilization of the resource
    - ✓ Availability of capital, market,
    - ✓ Competitiveness



3.2. Linkages between NTFPs and SFM

Although development and conservation circles have been interested in NTFPs for decades, there are a number of reasons for the general spread and upsurge of interest amongst them since the 80s, leading to the belief that the promotion of their sustainable use could lead to a win-win situation for poverty reduction and biodiversity conservation.

- The demand for many NTFPs is growing fast (e.g. medicinal plants) and their habitats and populations are increasingly threatened.
- Economically viable NTFP harvesting may be less detrimental for forest cover and biodiversity than timber harvesting.
- Sustainable incomes from NTFP harvesting and commercialization can provide sufficient incentives for forest and other natural habitat conservation
- The contribution of NTFPs to the livelihoods of the poor is often high.
- Sustainable NTFP harvesting and commercialization can contribute to poverty alleviation and sustainable livelihoods for people living in and around forests.
- Exploitation of NTFPs is often proposed as a potential means of ensuring sustainable forest management and conservation biology as opposite to logging for timber or conversion.
- NTFPs extraction is less destructive in harvesting than treating the for timber harvesting e.g. no felling
- NTFPs extraction also environmentally compatible
- Extraction of NTFPs was introduced as a combined solution for the development needs of local communities, forest degradation & deforestation.
- NTFPs harvesting could also provide an incentive to keeping the forest intact & managing it sustainably

- NTFPs were expected to offer a model of forest use which could serve as an economically competitive & sustainable alternative to logging
- **However**, this depends very much on: seasonal timing of harvest, timing of harvest in the plant life cycle, types of NTFPs extracted, quantity produced, demand for it, price of it, number of collectors & etc…..

3.3. Linking NTFPs and REDD+

3.3.1. REDD+: Why it came? and what does it means?

Deforestation and forest degradation are the second leading causes of global warming. Tropical forest clearing accounts for roughly 20% of the anthropogenic carbon emissions and destroys significant carbon sinks globally (IPCC, 2007).

The global response to climate change is coordinated through the United Nations Framework Convention on Climate Change (UNFCCC) and since early 2005, under the KP. Therefore, tackling the destruction of tropical forests is core to any concerted effort to combat climate change. Traditional approaches to halting tropical forest loss have typically been unsuccessful, as can be seen from the fact that deforestation and forest degradation continue unabated. REDD (reducing emissions from deforestation and forest degradation) incentivizes a break from historic trends of increasing deforestation rates and greenhouse gases emissions. It is a framework through which developing countries are rewarded financially for any emissions reductions achieved associated with a decrease in the conversion of forests to alternate land uses. Having identified current and/or projected rates of deforestation and forest degradation, a country taking remedial action to effectively reduce those rates will be financially rewarded relative to the extent of their achieved emissions reductions.

REDD provides a unique opportunity to achieve large-scale emissions reductions at comparatively low abatement costs. By economically valuing the role forest ecosystems play in carbon capture and storage, it allows intact forests to compete with historically more lucrative, alternate land uses resulting in their destruction.

In its infancy, REDD was first and foremost focused on reducing emissions from deforestation and forest degradation. However, in 2007 the Bali Action Plan, formulated at the thirteenth session of the Conference of the Parties (COP-13) to the United Nations Framework Convention on Climate Change (UNFCCC), stated that a comprehensive approach to mitigating climate change should include "policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries". A year later, this was further elaborated on as the role of conservation, sustainable management of forests and enhancement of forest carbon stocks was upgraded so as to receive the same emphasis as avoided emissions from deforestation and forest degradation.

Finally, in 2010, at COP-16 as set out in the Cancun Agreements, REDD became REDD-plus (REDD+), to reflect the new components. REDD+ now includes:

a. Reducing emissions from deforestation;
b. Reducing emissions from forest degradation;
c. Conservation of forest carbon stocks;
d. Sustainable management of forests;
e. Enhancement of forest carbon stocks.

Within its remit, REDD+ has the potential to simultaneously contribute to climate change mitigation and poverty alleviation, whilst also conserving biodiversity and sustaining vital ecosystem services. This potential for multiple benefits raises the crucial question of to what extent the inclusion of development and conservation objectives may help or hinder the overall success of, and negotiations for, a future REDD+ framework (explicitly for climate change mitigation). Having said this, prospective co-benefits can easily transform into prospective co-detriments, making the earlier question arguably irrelevant. Aside from whether consideration of such factors will promote or hamper the success and negotiations of a REDD+ framework, they are unquestionably important for the creation of a sustainable and equitable REDD+ process.

The details of a REDD+ mechanism continue to be debated under the UNFCCC, and the considerable financial needs for full-scale implementation have not yet been met. A final mechanism is therefore not yet in place and operating at scale. Despite this, in recognition of the need for urgent action if reducing deforestation is going to have a meaningful effect in terms of reducing emissions and mitigating climate change, REDD+ initiatives have already been instigated outside the auspices of the UNFCCC, both independently and in anticipation of a formal REDD+ mechanism.

3.3.2. The multiple benefits of REDD+

- When forests that would have been lost or degraded are retained or restored through REDD+,
    - Protection & enhancement of carbon stocks is not the only benefit.

Other benefits linked to the improved condition of forests like

⇒ Cleaner water and a lower risk of flood and drought,

⇒ Conservation of fertile soils,

⇒ Larger numbers of rare and threatened plant & animal species

⇒ Larger supply of non-timber forest products,

⇒ As well as increased availability of forest based job opportunities, livelihoods and income.

It also leads to wider social benefits through

⇒ Land tenure clarification,

⇒ Enhanced participation in decision-making & better governance.

- REDD+ relevant for **indigenous people** & **local communities** living in & around the forest.

3.3.3. NTFPs and REDD+

- NTFPs and REDD+ focus on achieving forest conservation & development through market based approaches.
- NTFPs and REDD+ are important for rural livelihood & thus poverty alleviation,
- NTFPs extraction/production is more compatible with biodiversity conservation & climate change mitigation
- NTFPs increases & secure forest ecosystem services
- Integrating NTFPs with REDD+ increases income opportunity of the local community
- NTFP in diversified forest management plans to offset the costs of reduced-impact logging
- NTFPs based forest management activities uses for biodiversity conservation, climate change mitigation and poverty alleviation.

- REDD+ strategies also used to enhancement of carbon stocks and opened up new opportunities for integrated management of NTFPs and environmental services.

Conclusion

Although NTFP and REDD+ are both market-based approaches for conservation and development, it is evident that not all the dimensions, scales and objectives are comparable. Both focus on achieving forest conservation and development, although NTFP projects focus on a more local scale, while REDD+ centers its objective within a much broader scenario for climate change mitigation. While NTFP projects can support conservation of biodiversity as well as other ecosystem services, REDD+, as originally designed, and seeks to address problems with the forest's carbon sequestration capability caused by deforestation, thus focusing on one ecosystem service as its primary objective. These conceptual differences should not disregard the similarities in the outcome of their implementation. By involving the market in the equation, NTFP promotion, where suitable, should be able to attain the goal of managed forests with little intervention or deforestation. This obviously serves climate change mitigation efforts and carbon stabilization goals as well.

4. Sustainable extraction of selected NTFPs: implications for sustainable development

4.1. Background

The production and processing of non-timber forest products (NTFP) may significantly increase the incomes and employment of low-income people in and around forests while preserving the ecological sustainability of the resources. However, there are relatively few successful examples of NTFP enterprise development combining profitability, equity and sustainability. Technology, a critical factor in enterprise development, includes equipment, tools, processes, products, materials, skills, and systems for converting inputs into outputs and distributing and using the outputs for consumption.

NTFP Producers and the Technology Gap

Small-scale producers of NTFP and other products often lack access to improved technologies that could increase their productivity and competitiveness. *Technology* encompasses knowledge of equipment, tools, products, processes, materials, skills and the organization of production and marketing. Small-scale producers do not always have the ability to conduct or testing of a new technology. Despite the potential benefits from development of technologies for small-scale producers, governments and universities or science and technology institutes have generally focused research on technologies for larger enterprises. Even where research has been conducted on behalf of small-scale enterprises, the next step of encouraging the commercial manufacturing and use of these technologies is often absent. External assistance can play a catalytic role in promoting the use of more productive technologies for small-scale producers. Table 1 indicates some of the potential beneficial impacts of technological assistance. They relate to increases in productivity, improvements in product quality, and increases in local self-sufficiency and development of local skills. The degree to which they occur varies according to local conditions and type of product.

Changes in technology can also make existing products and production processes uncompetitive, shifting access to resources and employment to different groups. A common example is the substitution of natural products by synthetics, as in the case of pine oleoresins, some medicinal plants, natural dyes, etc. Also, increased value of throughput may create unsustainable demand on the resource. This highlights the need for a full assessment of the potentials of technology as well as all its side effects. Since the appropriateness of a technology for local conditions can vary considerably across and within countries, some adaptation is often required before a technology can be transferred to another location. The up-front costs of developing, adapting and demonstrating new technologies can be amortised over a long time because the benefits continue to accrue as use of the technology spreads. The adoption of technologies by small-scale producers is frequently characterised by an S-shaped curve. At first, the number of adopters may be low, but it gradually rises at an increasing rate before leveling off as saturation of demand is achieved. Consequently, the cost effectiveness of technology promotion can be increased by expanding the resources available for replication and diffusion activities.

Technology dissemination projects need to be carefully designed to ensure their continued impact after project activities have concluded. By working with the private sector and creating market-based incentives for production and use of more productive technologies, the conditions necessary for continuation can be achieved. It is usually easier to upgrade the technologies of existing enterprises than to establish new ones because existing firms have some investment in place and the entrepreneurs and employees have demonstrated business and technical skills (Jeans *et al.* 1991). Government policies can also have a large and differential impact on the profitability of production at various scales and on the technologies used (Stewart 1987; Stewart *et al.* 1990).

A. Increases in productivity

1. Faster production to increase sales volume
2. Savings in labour time
    a. Cost savings
    b. Freeing up unpaid household labour for other purposes
    c. Shifting of labour to higher-valued uses of time
3. Substitution of lower-cost materials
4. Increased process efficiency to extract more product from a given amount of raw material or allow use of lower-cost raw materials
5. Reduced fuel costs
6. Lower working capital requirements to reduce interest costs and the burden of debt
7. Lower fixed capital requirements
8. Increased output to open up bulk markets
9. Lower product prices for consumers

B. Improvements in product quality

1. Improved product consistency and reliability
2. Higher sales prices for producers due to better grade goods
3. Allow a switch to higher-valued products
4. Better packaging for bulk markets

5. Generation of marketable by-products
6. Greater durability of products for consumers

C. Increases in local self-sufficiency

1. Use of locally available materials
2. Increased marketing independence
    a. Greater farm-level processing of agricultural products to reduce the need for immediate sale at peak harvest periods when prices are low
    b. Better organization of marketing channels to expand information and reduce transaction costs
3. Greater capacity for local repair and maintenance of equipment
4. Decentralization of power or fuel supplies for greater reliability
5. Better availability of products for consumers

D. Development of local skills

1. Increased capacity for further innovation
2. Enhanced ability to enter new product lines or markets
3. Creation of new possibilities for local manufacturing

4.1.1. Resource Sustainability and Technologies for collection of NTFPs

Resource sustainability is the ability to maintain a desired level of production indefinitely without reducing the stock of the resource. Sustainable resource use requires careful selection of the species and sites as well as control of the harvest rates. Poverty may force NTFP gatherers to maximize short-term income by harvesting as much as possible, even at the expense of future income. Lack of long-term security adds to the poverty factor. This problem is exacerbated if the number of NTFP gatherers increases through population growth or migration. NTFP that occur in low density are particularly susceptible to over-harvesting if they are valued highly enough to be gathered.

Providing a way for NTFP gatherers to earn greater returns and have a stake in long-term resource sustainability through processing could help reduce short-term over-exploitation. However, higher NTFP prices associated with local processing might also increase the incentive for people to devote more time to collecting these resources. Profitable collection and processing does not guarantee that sustainable practices will be followed, particularly if there is uncontrolled access to a common-property resource.

Government agencies generally lack the budget and staffing to enforce restrictions on harvesting open-access resources effectively through a policing approach because the areas are large and often remote. Even if a ban on trading certain NTFP does not stop harvesting, it may block gatherers from adding value locally through processing. NTFP projects may need to help establish local systems for controlling access or limiting the amount harvested by individual gatherers, while ensuring an equitable distribution of the benefits to the community. Equitable control of access to common-property resources often combines individual and collective controls or a shift towards production on private lands (Arnold 1995).

The sustainability of a NTFP depends on the rate of harvesting relative to regrowth and regeneration as well as the stage, timing and method of harvesting (Peters 1994; de Silva and Atal 1995). Due to poverty and poor knowledge of alternatives, people may use resource-damaging harvesting technologies, especially if this activity is not very profitable. As a resource becomes more scarce over time, new methods may be needed for collection and regeneration or product diversification. The harvesting technology can also affect product quality. NTFP development can help conserve natural forests by increasing their perceived value to local people due to the income generated while potentially maintaining biodiversity, unlike most alternative land uses (Peters 1994). Most NTFP can be harvested sustainably if collection builds on indigenous technical knowledge and institutional arrangements exist or are established to maintain the resource (Richards 1993).

NTFP development is more likely to encourage forest preservation when the products are of high value and relatively abundant and a sizeable number of people can derive a significant share of their income from the resource. NTFP commercialization can also generate funding for conservation activities in environmentally sensitive areas (Plotkin and Famolare 1992). However, it can also lead to over-exploitation and loss of biodiversity if the appropriate control mechanisms are not put in place.

The fact that NTFP can be harvested sustainably does not necessarily mean that they will be harvested sustainably. Excessive or careless NTFP collection can have negative impacts on ecosystems. The magnitude of the impacts depends on the species composition of the forest, the nature and intensity of harvesting, and the characteristics of the species harvested (e.g., primary species, early pioneer or secondary species, or late secondary species; Peters 1994). Serious damage can be inadvertently caused to other plants or animals in harvesting NTFP. Processing may also have significant environmental impacts.

However, even if NTFP are harvested sustainably, they may not make a major contribution to long-term conservation of forest resources because of the 1) tendency toward domestication or replacement of NTFP with synthetics; 2) inconsistent supply of most extractive products; 3) lower short-term income potential from NTFP than from unsustainable logging, mining, agriculture or ranching; 4) small size and volatility of export markets for many NTFP; 5) failure of governments to address broader land and resource-use rights; 6) preferences of people for earning a living through settled agriculture rather than NTFP collection; and 7) lack of familiarity of new migrants with sustainable harvesting of NTFP (Richards 1993).

NTFP collection probably cannot stem pressures for clearing forest land for commercial logging, agriculture, grazing or mining, which may be more profitable than NTFP collection in the short run (Reining and Heinzman 1992). Local people might not be able to guard forests from illegal loggers or colonisers. The bigger problems include the failure of governments to address broader land and resource use rights and preferences of people for earning a living through settled agriculture rather than extractivism (Reining and Heinzman 1992; Richards 1993). For these reasons, it is important to identify and alleviate any significant resource and environmental impacts of NTFP collection as they occur.

The number and size of plants harvested or animals captured and the area affected should be monitored and the rates of harvesting adjusted to achieve sustainable levels. Establishing new institutional arrangements for monitoring and mitigation (such as collaboration between producer groups and NGOs) can be important in achieving resource sustainability and minimizing negative environmental impacts of enterprise development.

4.1.2. Technologies for Pre-processing or processing of NTFPs

Many NTFP can be pre-processed or processed through relatively simple and available technology, although it may not be known in the areas where they are found. *Pre-processing* includes storage and preparation of a product for sale to processors or intermediaries. Lack of pre-processing or poor pre-processing can reduce the incomes of NTFP gatherers and the sustainability of the resource. It can lower the product price due to inferior quality or reduce the saleable portion of the harvest, making it necessary for gatherers to harvest larger quantities (Reining *et al.* 1992).

4.2. Production, handling and quality control of Gums and Resins

4.2.1. Production processes and gum handling

History of Gum-Resin Production in Ethiopia

Oral legend tells that myrrh and incense production and trade in Ethiopia goes back to the Aksumite Empire that flourished around 500 BC (Gebremedhin, 1997). The introduction of Christianity to the country around the 3rd century A.C. is assumed to have increased the production and trade of the products. Nonetheless, there hardly exists historical recordings and other hard evidences to unequivocally conclude such claims of ancient commercial production of myrrh and incense in Ethiopia. Recorded history for commercial production is available only since the 1940s (Taib, 1982), when Italians introduced incense production to Ethiopia through Eritrea. Production in Eritrea was further introduced from Somalia. From there commercial production further extended southwards to other parts of the country over time including Tigray, Metema, Beneshangule, Borana and other parts (Fig. 1). Organized production and trade of gums and resins by local companies began in 1960s following the founding of a private company called Tigray Agricultural and Industrial Development Share Company (TAIDL), which was co-owned by the then government of Ethiopia and some private individuals. The company operated until 1974 when it was nationalized by the socialist government, which soon established a state based company called Natural Gum Processing and Marketing Enterprise (NGPME).

NGPME is assumed responsible for the further expansion of the gum and resin production to the rest of the country. NGPME was also active in technology shopping such as tapping equipments for improved exploitation from other neighbouring countries principally Sudan and Somalia (Fig. 1). For 17 years (1974 – 1991), NGPME operated alone, being the sole enterprise responsible for the production and marketing of gums and resins in Ethiopia. Since 1991, following the fall of the socialist regime and the beginning of a free market economic policy, several private entrepreneurs renewed interest in gum and resin production and marketing. Today, about 34 private companies are engaged in the production and /or trade of gums and incenses in various sites throughout the country.

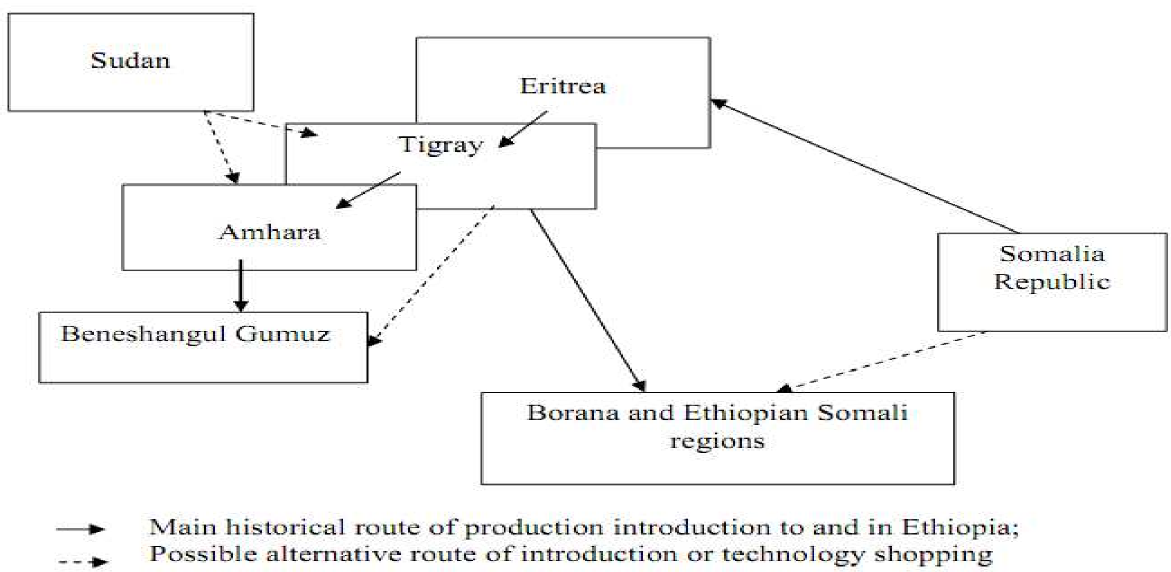


Figure 6: Historical development of commercial gum and resin production in Ethiopia

The production of various gums and resins vary based on the type and place of production. Common to all, however, is the fact that production and harvesting is seasonal and performed solely during dry seasons. Production during rainy seasons is not recommended due to rapid quality deterioration in connection to high moisture content. Today's gums and resins production system in Ethiopia can broadly be sub-divided into two: (i) production by tapping and (ii) collection on naturally oozing gums and resins.

(i) Tapping

Tapping is artificial wounding of stems and branches of trees for the production of gums and resins. It involves shallow blazing (wounding) of the stems and branches of trees by shaving off the bark using sharp instruments, which are locally called Mingaf or Sonke. When the stems and branches are blazed, incense begins to flow or ooze through the openings created by the wounds. These incense tears start to solidify and granulate upon exposure to wind and sun radiation. Letting the tears to stay on the trees for sufficient length of time is important for maturity of the tears and to avoid their clamping into ungranulated masses. In Ethiopia, tapping is commonly practiced for Tigray type incense production from B. papyrifera. The tapping and collection of gum olibanum from B. papyrifera is carried out following a specific pattern starting from mid October up until the onset of the rainy season, usually early June. Due to the mono-modal rainfall pattern in the north, production and collection is practiced for an extended 8-9 months each year. Conventional tapping practiced on B. papyrifera begins with the first cycle by wounding the stem of the trees at three spots, separated approximately by 25 - 50 cm distance from each other.

Wounds are often made on the eastern and western sides of the tree to allow sufficient exposure to sunlight for quicker drying of gums. However, on big trees tapping spots could be up to four or more. Successive tapping cycles involve refreshments of older wounds by removing barks from the upper edges of the former blaze (wound) and by carving down by 2 cm of the lower edge, until the whole wound size reaches 10 cm width at the end of the year. Wounding and refreshments continue every 2-3 weeks interval until the onset of the rainy season. Usually, a tree is tapped and refreshed 8–12 times per production season.

Incense tears are picked from the stems before refreshment and put into collection vessels made of local materials (Fig. 3.5). Refreshment of wounds at the right time is very crucial. If wounds are not refreshed at the right time, old wounds may heal and plants may take longer time to reinitiate production of adequate and superior quality resins during the successive delay of wounding. This will also reduce annual yields. The number of wounds per tree should be limited. Too many wounding will result in smaller or dusty tears, which are generally regarded as inferior quality.

(ii) Collection on natural oozes

Collection for most of the gums and resins, particularly those produced in the south and southeast are produced from collection on natural exudates (Fig 3.6). The reason for the absence of artificial tapping is variably indicated. In some studies it is reported that abundance of the resources for the current market demand is more than enough that there is no reason to invest effort (Lemenih et al., 2003; Worku, 2006). Others comment that farmers are unaware of the process of tapping for the production of good quality and quantity gums and resins (Fitwi, 2000).

There are two harvest seasons for the southern production and this is due to the bimodal nature of the rainfall. The production seasons are: December– February (following the main rain in October- December) and the second major production is between June – September (following the short rain in March - June). Collectors, which are mostly cattle herders, hand pick gums from tree trunks and branches. Collections are not restricted to gums on trees but also fallen pieces are picked often from the ground, when falling while picking.

Organization of the production system

In the case of B. papyrifera gum production, there are recognized production systems. Three systems are commonly observed. The first system is where producing enterprises (private or state) employ and organize the production themselves. In this case the enterprises hire experienced personnel as coordinators and other as tapers, or sometimes the coordinators are contracted and they (coordinators) employ tapers. The enterprises provide the workers with all basic necessities such as cooking utensils, cloths, medicines, food items, petty cash and tools. All the provisions are in the form of credit/loan to be deducted from their wages at the end, except medicine, which is provided free. Then, tapers are organized under a work team commonly known as "squadra" and a number of squadra are organized under a coordinator. Each squadra submit the olibanum collected to the coordinator, and the coordinators deliver the gum to the enterprises. Final payment, which is based on piece rate, is effected after delivering the collected olibanum.

The second system involves concession, in which individuals who have knowledge and experience in production and also have the financial capability to cover the food and transportation costs of tapers are selected to sign agreement with licensed gum/incense producing companies. Depending on the concession site size, the concessionaries employ tapers and provide them with basic necessities. All these expenses are covered by the concessionaries and the payment to tapers are determined by a contractual agreement of wage per season. Unlike the first case, the concessionaries do not provide tapers with medicine and cloths. The concessionaries finally deliver their produce to the companies.

The third system, which is less common, is where farmers or locals are organized as roducer cooperatives and produce gums and resins, which they formally sell to whole sellers and gum exporters. This version is nowadays growing in importance. With the increasing recognition of the rights of locals to benefit from the resources nearby, there is a growing trend of organizing locals in many of the producing areas such as Metema, Borana and Tigray in the form of local cooperatives to produce and sale. Such actions can encourage local people to enhance production of the goods while conserving the resources (Lemenih et al., 2007; Worku, 2006).

For the southern production, except the recently emerging cooperative based collection, there has been no systematic production organization as such. Farmers, regularly women and children, gather gums and resins of their encounterance as subsidiary activity while herding cattle. However, during hard times as well as with good market demand, males and adults also involve in collection, while poor households often engage the entire family (Worku, 2006). Daily collections are put together and weekly or occasionally the gathered quantities are delivered to local markets and sold to local retailers. Collectors use different local materials such as old milk vessels and sacks for field collection and handling.

The continued climatic vagaries in the drylands of Ethiopia is alerting federal and regional governments as well as other development actors mainly NGOs to focus on Improved management of the woodlands and integrate the production of their gum-resins into the wider livelihood strategies. Consequently, not only State institutions but also several NGOs are nowadays engaged in improved management and utilization of the woodland resources. These NGOs are engaged in training, organizing and facilitating woodland management and production of gum-resins. At the same time, there is a growing national interest to intensify the production of gums and resins (PASDEP, 2005), mainly because of their increased contribution to the State's foreign currency earning, but also because of the rising global demand. For instance, the State's plan for the period between 2005 -2010 shows a doubling of gum-resin production and export (PASDEP, 2005).

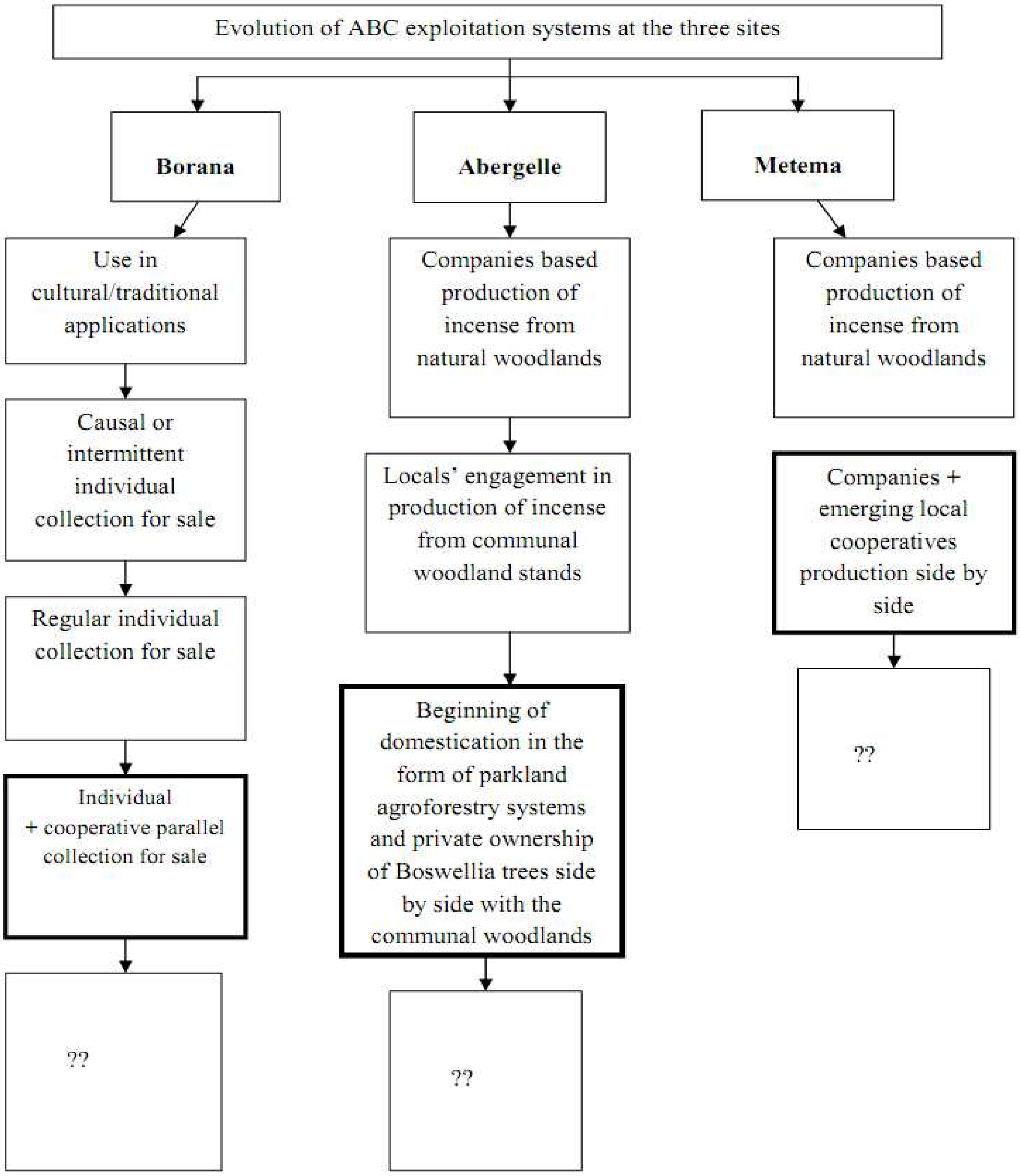


Figure 7: Evolution of gum and resin exploitation systems at the three case study sites

(Tick box represents current system, while the question mark is used to portray what the future development might be).

These new initiatives are evolving with them new production systems. One of the common production models dominating gum–resin exploitation at the present is the cooperative model. This model may represent the dominant future gum-resin resources exploitation system in the country as it may solve bottlenecks related to: (i) the public ownership policy of land and resources (woodland or forest); (ii) the arduous and labour extensive nature of gum and resin production; and (iii) the current policy to encourage cooperatives as a viable marketing model in the country.

Post harvest handling of gums and resins vary based on gum type. In the case of gum olibanum of the Tigray type, collected gums from the trees are seasoned in the field by spreading on beds made of local materials in temporary shades. Seasoning is essential to avoid clamping and muddening of the tears.

4.2.2. Post-harvest handling

Processing and grading of Tigray type gum olibanum

After seasoning in the field under shades, the incense is transported to permanent warehouses where further processing is carried out. Processing of Tigray type olibanum involves cleaning, sorting and grading of the gums according to their size and colour. The whole operation is manual and is usually done by women (Fig. 2.8). Grading of olibanum involves sorting it into 7 different grades using size and colour criteria (Table 2):

Table 12: Grades and their descriptions of gum olibanum (Tigray type)

Grade	Grade Name	DESCRIPTION	Ratio%
1st	1 A	Size 6 mm and above white Grade "A"	22%
2nd	1 B	Size 6 mm and above creamy white Grade "B"	9%
3rd	2	Size between 4 and 6mm	11%
4th	3	Size between 2 and 4mm	8%
5th	4 A	Special brown in colour any size	19%
6th	4 B	Normal black in colour any size	17%
7th	5	Powder and bark no size limit	14%

Grading myrrh and gum arabic

Myrrh is graded more or less the same was as Tigray type olibanum. Grade 1A has a bright red color and grade 1B is brown. The rest of the grading system is similar to that of Tigray type olibanum. The grading system for gum arabic is not yet developed in Ethiopia. However, quite a substantial amount of cleaned gum arabic is exported.

4.2.3. Quality of gums and resins

The chemistry of gums and resins

One of the key factors that downplayed on gums and resins trade in Ethiopia is failure to guarantee consistent quality in supply. Importers of gums and resins prefer for raw materials of consistent and predictable quality with reliable supply. One of the major quality deteriorating practices is adulteration, driven mostly by the greed of the producer farmers to increase trade volume. This is so because traders have no means to justify whether the gums and resins in the trade batch are pure or not.

Most of the gums own similar look in terms of colour (e.g., gum arabic of A. senegal and gum from A. drepanolobium or A. mellifera) so discerning by eye inspection is hard and can be misleading. In fact, adulterants are purposefully selected based on colour and textural similarities with the genuine products. Therefore, important measures to ensure gum and resin qualities are chemical characterization of each type, testing of each batch and labelling with localities and botanical origin. Chemical characterization is essential because, gums from different species, for instance, A. senegal and A. seyal, which are designated as gum arabic in trade, exhibit characteristics that are intrinsically different. For this to be made possible, establishment of commercial test laboratories and setting of standards are fundamental. This process, when applied widely, can train farmers and retailers not to mix, but to collect and trade gums and resins of different botanical sources differently. Recognizing the differences in gum quality and their end uses (applications) between the different species and/or even varieties is important in producing gums and resins that guarantee customer (importers) satisfaction and assure users on safety grounds.

From the application sides, there are stringent regulations for almost all gums, specifically those used as food additives, such as gum arabic (A. senegal origin). Most of these gums are not only tested for chemical consistence but also subject to extensive toxicological control by countries, organizations and users of the products. This demands quality assurance that surpasses labelling of products for botanical source and localities. Proper handling of the products from collection to shipment is crucial in avoiding any toxicological contaminations. To satisfy these demands of consumers, and to win high market demands for gums and resins, supply must conform to sets of chemical specifications (Seif and Zarroug, 1996). Nowadays, users also want traceability to source localities, and guarantee that ensure a product, which is free from any risk.

With respect to chemical characterization of gums and resins in Ethiopia, several works have been done in recent years, although a lot sill remains to be done. Available information on the chemistry of some of the gums and resins from Ethiopia are presented in the following sections.

Gum arabic

Gum arabic is a complex arabinogalactan type polysaccharide exudates of Acacia trees (Sanchez et al., 2002). The exact chemical and molecular structure, however, differs according to the botanical origin of gum and these differences are reflected in the analytical properties, functional properties and uses of gum arabic. The product is essentially used as a technical product. It is often blended with other gums or materials to produce precise ingredients for food and pharmaceutical applications (Holmes, 1997). Vast sums of money, which goes into developing new product lines, also demand that ingredients must be of a relatively invariable nature.

The increasing international pressure towards tighter trade specifications and labelling regulations, identity and purity has led to the Revised Specifications (FAO/WHO–JECFA) where gum arabic is defined as gum originating from A. senegal or closely related species, with a specific optical rotation range of –26° to –34° and a Kjeldahl nitrogen content of 0.27–0.39% (FAO, 1995). Gum arabic contains neutral sugars (L-rhamnose, L-arabinose, and D-galactose), acids (D-glucuronic acid and 4–methoxyglucuronic acid). It also contains some cations such as calcium, magnesium, potassium, and sodium as well as some heavy metals such as lead, cupper, cadmium and zink. Protein is also one of its constituents. Yet, the exact values and relative proportions of some of the above analytical parameters of gum arabic vary depending on botanical origin and geographical location. Table 3.2 presents the laboratory analysis data for the physico-chemical characteristics of the gum arabic samples from A. senegal. Physically the gum is pale–white to orange–brown in color, is solid and brakes with a glassy fracture, just like gum arabic of high quality described in literatures (FAO, 1999). The gum is tasteless and odorless. It is readily soluble in water and insoluble in ethanol. The lead content of the gum arabic sample is negligibly low to be detected at the laboratory investigation on atomic absorption spectrometer.

Given that gum arabic is used as food additives the amount of heavy metals like lead has to be minimal, and this is set as less than 2.0 ppm (FAO, 1999), to which the gum arabic from Acacia senegal of central Rift Valley conforms. The characteristics of the gum arabic from the central Rift Valley of Ethiopia was also evaluated against several international specifications and characteristics of gum arabic from renowned sources such as Sudan, Uganda and Kenya. The evaluation shown in Table 3 showed that the gum satisfies well specifications set, and display similar or better characteristics with those from Sudan, Kenya and Uganda.

Table 13: Data on the physico-chemical property of gum arabic from A. senegal in the Central Rift Valley of Ethiopia

Characteristic	Value
Moisture content (%)	15
Ash content (%)	3.56
Viscosity (Centipoise) …at 10 (gl^{-1})	0.9954
…at 7.5 (gl^{-1})	0.9552
pH (25% sol.)	4.04
Nitrogen content (% w/w)	0.35
Protein (%; N x 6.6)[a]	2.31
Specific rotation (degree[a])	–32.5
Tannin content (% w/w)	0
Gel (25% sol.)[b]	Moderate
Ca (g/100g)	0.7
Mg (g/100g)	0.201
K (g/100g)	0.95
Na (g/100g)	0.014
Fe (g/100g)	0.001
P (g/100g)	0.6
Pb (g/100g)	ND
Mn (g/100g)	ND
Co (g/100g)	ND
Cu (g/100g)	ND
Zn (g/100g)	ND
Ni (g/100g)	ND
Cd (g/100g)	ND
Cr (g/100g)	ND

Source: Yebeyen et al., 2009; ND = Not detected; a = at 25 °C temperature; and b = Based on the classification category: no gel, light gel, moderate gel; and heavy gel after Chikamai and Banks (1993).

Table 14: Gum arabic from Central Rift Valley of Ethiopia compared with international specifications and known destinations (For values of chemical parameter for Ethiopian gum, see table 3 above)

Quality parameter	International specifications by some organizations				Values for gum arabic from four countries[a]	Values reported by some studies from different areas				Evaluation of the gum arabic from CRV[b] of Ethiopia
	JECFA	USP	BP	IP		Mhinzi & Mrosso (1997)	Karamalla et al. (1998)	Idris et al. (1998)	Al-Assaf et al.. (2005)	
Moisture content (%)	< 15	< 15	< 15	< 15	13–15	14.1–15	8.1–14.05	12.5–16		Good
Ash content (%)	< 4	< 4	< 4	< 4	3.0– 3.9	3.8–4.5	2.75–5.25			Very Good
Intrinsic viscosity (ml/g)					15 – 22		1–73		9.7 – 26.5	–
pH (25% sol.)					4.3–4.4		4.3–5.1			Fair
Nitrogen content (% w/w)					0.27 – 0.44	0.28–0.33	0.23–0.43	0.22–0.39		Very Good
Protein %					1.8 – 3.0	1.75–2.06		1.5–2.6	1.8 – 2.1	Very Good
Specific rotation (degrees)	NS	NS	NS	NS	−30 - −34	−25 - −26	−23 - −29	−27 - −36	−29 - − 33	Very Good
Tannin content (% w/w)	0	0	0	0	0	0.28–0.52				Very Good
Gel(25% sol.)					Notdetermined					–
Ca (g/100g)						0.43–0.72				Very Good
Mg (g/100g)						0.02–0.29				Very Good
K (g/100g)						0.09–0.98				Very Good
Na (g/100g)						0.01				Very Good
Fe (g/100g)										–
P (g/100g)										–
Pb (g/100g)										Very Good
Mn (g/100g)										Very Good
Co (g/100g)										Very Good
Cu (g/100g)										Very Good
Zn (g/100g										Very Good
Ni (g/100g)										Very Good
Cd (g/100g)										Very Good
Cr (g/100g)										Very Good

Source: Yebeyen, 2009; NS – Not specified; a = Ranges of values for *A. senegal* var. *senegal* from four countries: Sudan, Nigeria, Kenya and Uganda (Source: Chikamai, 1997); JECFA = Joint Expert Committee for Food Additive; IP = international pharmacopeia; BP= British pharmacopeia; USP = United State pharmacopeia) b = CRV stands for Central Rift Valley of Ethiopia.

Aromatic gum resins

Gum resins (olibanum, myrrh and opoponax) obtained from different species differ in their quality, which reflect their chemical compositions. The chemical compositions of their volatile oil account for the sensory characteristics of the products and determine their fragrance and flavor applications. In other words, most applications of aromatic gum resins revolve around their volatile oils. Nonetheless, the non-volatile constituents are also essential as these are also certainly responsible for some of the biological properties of the products and also employed in several applications such as in medicine (Copper, 2005).

Myrrh contains 57-61% water-soluble gums, 7-17% volatile oils, and 25-40% alcohol-soluble resins and 3-4 % impurities. Olibanum is composed of about 5-9% essential oil, 65-85% alcohol-soluble resins, and the remaining water-soluble gums or 8-9% essential oil, 45-50% resin, 30-40% gum and 4-5% impurities. The volatile oils of the gum resins consist mixtures of mono-sesqui- and diterpenoids, the precise composition being varying from resin to resin based on species and source locality. The non-volatile components constitute numerous triterpenoids of the lupan, oleanolic and ursolic acid types. Boswellia resins contain components such as ɑ- and β-boswellic acids, which are the main active constituents for their medicinal applications.

a) Essential oil composition of olibanum

The most essential ingredients of olibanum are their essential oil (volatile oil). The constituents of these volatile compounds in terms of composition and amounts vary between species and within species due to many factors like geographical location, collection time and product handling. There are works done on the characterization of the essential oils of Boswellia species, but Boswellia papyrifera received more attention than others. Major components in the essential oils of Boswellia papyrifera of Ethiopian origin are octyl acetate ranging from 50 to 90%, α-pinene (6.1%); camphene (0.6%); β-pinene (2.0%); myrcene (1.7%); limonene (4.8%); 1-octanol (5.9%); linalool (3.6%), octyl acetate (46.8%), and geraniol (1.1%) (Dagne et al., 1997; Dekebo et al., 2002). Whereas the essential oils from Boswellia neglecta is mainly composed of hydrocarbon monoterpenes of α-thujene (26%), α-pinene (20%), 4-terpineol (15.7%), p-cymene (4.5%), camphore (2.8%), and β-pinene (1.9%) (Dagne et al., 1997).

A recent report on yield and chemical constituents of different grades of B. papyrifera gum resins is presented in Table 3.4. In all the grades the major component is n-octyl acetate and accounts for more than 65%, except in grade 5 which contains around 60%. The essential oil from Grade 1 sample is rich with octyl acetate content of 65.25% followed by n-octanol content of 4.5%. From the table of chemical composition, it is realized that grading and sorting of frankincense has no value in terms of essential oil production. The amount of n-octanol found in grades 4 and 5 is 1.7 – 2.0 times higher than that found in grades 1A, 2 and 3. However, the variation in the chemical composition of volatile oils may arise due to season of tapping (incision time), cycle of tapping and geographical location (Fengel, 1984).

b) Essential oils of myrrh and opoponax

The volatile oil of myrrh has been shown to contain terpenes, sesquiterpenes, esters, aldehydes and alcohols. Seven sesquiterpene hydrocarbons, a furanosesquiterpenoid oil and furanoidiene have been detected in the volatile oil of C. quidotti or opoponax.

4.2.4. Quality control

The quality of gums and resins in Ethiopia are affected by factors such as botanical origin, adulteration, collection and handling of the products.

Gum arabic

In Ethiopia gum arabic is produced from A. senegal and A. seyal species. In most cases the gum of these two species are collected, handled, transported and traded separately. However, gums from different varieties are not kept separately but are all traded as gum arabic. Adulteration is a major bottleneck in gum arabic trade. Often gums from different species such as A. mellifera and A. drepanolobium are used intentionally as adulterants to gum arabic to increase trade volume. An immediate improvement in controlling the quality of gum arabic lies on training collectors to avoid adulteration, and simultaneously to train traders and suppliers to label their gum products by variety and locality.

Table 15: Composition (%) of the essential oils of different grades (G-1A to G-5) of frankincense from Boswellia papyrifera (G stands for grade)

SN	Compound	G-1A	G-2	G-3	G-4N	G -5
1	α - Thujene	0.29	nd	nd	nd	nd
2	α - Pinene	2.51	1.95	0.45	2.36	1.14
3	Camphene	0.69	0.50	nd	0.58	0.38
4	Sabinene	1.23	1.06	0.26	1.90	0.79
5	α -Pinene	0.52	0.43	nd	0.45	0.32
6	Myrcene	0.57	0.41	nd	0.40	0.26
7	n-Hexyl acetate	0.81	0.78	0.46	0.96	0.55
8	p-Cymene	0.31	nd	nd	0.33	0.28
9	Limonene	1.74	1.37	0.56	1.62	1.50
10	1,8-Cineole	1.69	1.67	0.73	1.60	1.28
11	Trans-Ocimene	1.13	1.83	nd	nd	nd
12	n-Octanol	4.51	3.63	4.55	7.46	7.75
13	Linalool	2.00	1.89	1.81	Nd	1.89
14	Endo-borneol	1.31	1.06	0.96	1.96	1.00
15	4-Terpineol	0.22	nd	0.32	nd	nd
16	α -Terpineol	0.47	0.44	0.46	0.51	0.42
17	n-Octyl acetate	65.25	68.76	69.08	67.87	60.89
18	Bornyl acetate	2.50	2.43	2.97	2.24	2.07
19	Caravacrol	0.96	nd	0.25	nd	nd
20	Unidentified	0.22	nd	0.26	0.30	0.28
21	Neryl acetate	0.38	0.40	0.25	nd	0.27
22	Geranyl acetate.	0.43	0.42	0.50	0.49	0.50
23	n-Hexyl hexanoate	nd	nd	nd	0.23	nd
24	n-Decyl acetate	0.50	0.42	0.57	0.50	0.53
25	Hexyl caprylate	0.21	nd	0.39	0.24	0.26
29	Incensole	0.59	0.58	1.25	0.28	1.40
30	Incensole acetate	2.51	3.12	5.37	1.51	5.80
Total		99.03	95.57	97.94	95.59	97.63

Retention indices were obtained relative to alkane mixture of C8-C30 and C32, product of Aldrich-sigma compound., nd = not detected. G-4N refers to the category of Grade Four Normal

Gum olibanum and myrrh

With respect to quality control, frankincense products in Ethiopia are grouped into two: the

Tigray type olibanum and the others. The Tigray type olibanum is produced from B. papyrifera, which exist in the forests of the northern and northwestern lowlands as the only Boswellia species, and adulteration with gums and resins from other similar species does not exist. Thus, Tigray type frankincense is the purest in terms of botanical origin. Furthermore, sorting and grading for this frankincense is well advanced due to long history of processing. The granules are well sorted, graded and shipped being purified into different quality grades. On the other hand, Borana and Ogaden type frankincense produced in the south, southereastern and eastern lowlands are characterized by poor quality originating from mixing of gums and resins from different botanical origins. It is not even possible to tell whether these two olibanums are different, and the exact species of their origin. This is because gums and resins from B. neglecta, B. rivae, B. ogadensis and B. microphylla are mixed either intentionally or unintentionally. Even some of the batches from these regions contain gums and resins from some species of Commiphora due to their resemblance in colour and scent.

Handling and production systems for Borana and Ogaden type olibanums are not well developed as compared to the Tigray type. Grading is less practiced and collection is restricted to natural exudates. Problem with collection on natural exudates that affect quality includes over exposure to radiation that bakes the resins and discolour them, or premature collection that lead the gum to be messy loosing granulation due to high moisture content. Sometimes collections are made on fallen granules from the ground, which contaminates them with soil and other foreign materials. Careless storage and use of inappropriate containers are also common quality degrading factors in all sorts of olibanum products in Ethiopia. Storages and transportation with substances such as petroleum and volatile items is often common in the local areas. Containers used for transport and storage should be clean and airtight (Fig. 3.10), and that collected olibanum stay for quite sometimes in the field under high temperature conditions. The prolonged stay under high temperature and in perforated containers can cause loss of significant proportion of their essential oils, leading to quality degradation of olibanum.

4.3. Medicinal and Aromatic Plants

4.3.1. Medicinal and aromatic plant species

Aromatic herbs

- Eg. Mint, Sweet balm, lavender, save, thyme, rosemary, fennel, ajedrea, palma rosa (Tegsar), *pelargonium graveolens* (Geranium). Symbopogon winterianus (nardos sar)

Medicinal herbs

- Eg. Artemisia annua, rosemary, Chamomile – (*Anthemis nobilis),,* Garlic - (*Allium sativum),* Marigold- (*Calendula officinalis*), Peppermint – (*Mentha piperita),* Sage - (*Salvia officinalis*), Aloe vera,, Lavender, Parsley, cymbopogon citratus

4.3.2. Harvesting/extraction techniques

Guidelines for the Sustainable Harvesting of Traditional Medicinal Plants

(a) Guidelines for root harvesting

- In order to ensure sustainable harvest of root material we recommend you follow these rules: Dig the root at a considerable distance, at least 30 cm, from the main stem or tap root. Avoid severing of the tap root. After digging cover the hole to ensure protection against infection and invasion by pests.

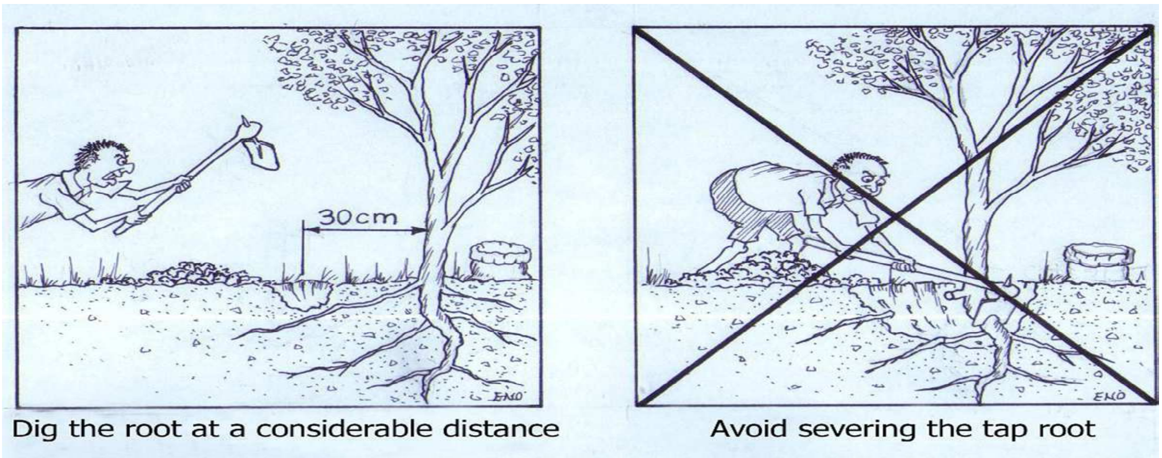


Figure 8: Guidelines for root harvesting

(b) Guidelines for bark harvesting

Peel the bark from the tree on the side of north to south than on the East and West side. Remove the bark in long vertical strips using knife. Do not practice ring barking, which is the cut of off entire rings around the tree. Leave some inner bark to protect the wood. apply a piece of wet cow-dung to the bark wound. This will prevent the wound from drying out, though it does not facilitate bark recovery or prevent the development of insect infestation or development of infections on the wound

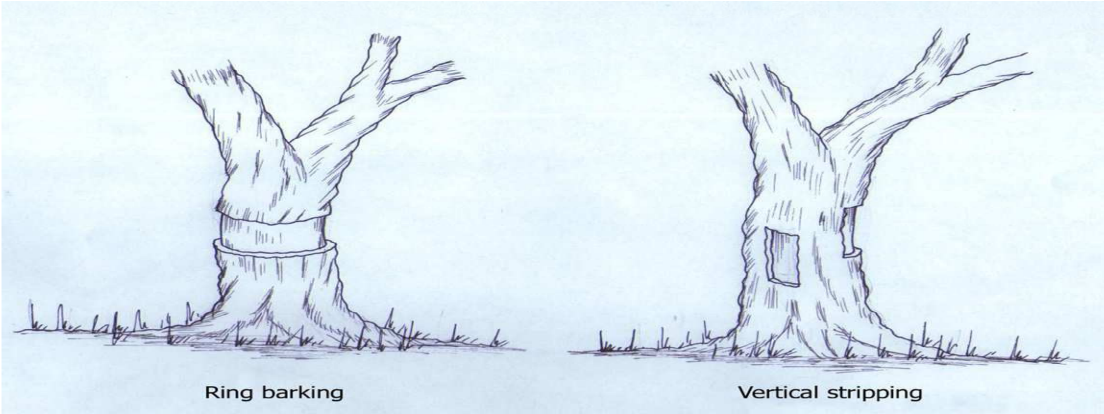


Figure 9: Guidelines for bark harvesting

(c) Guidelines for leaf harvesting

In most cases, leaf harvesting is regarded as least destructive form of harvesting to the plants. But we should not harvest all the leaves. In order to ensure sustainable harvesting of leaves is recommended that one can: Pluck individual leaves instead of leaf striping

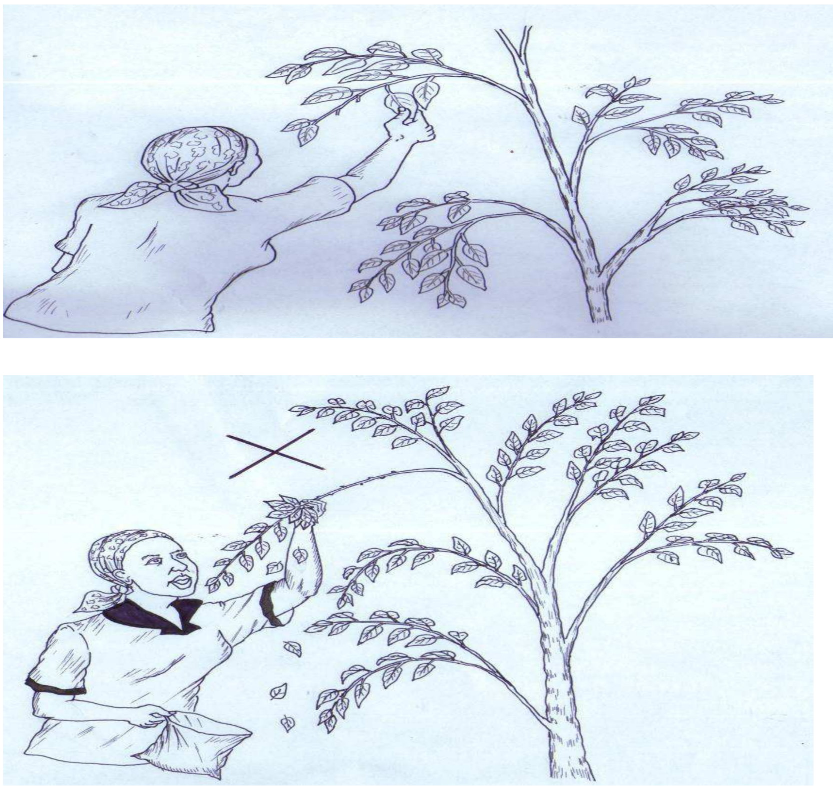
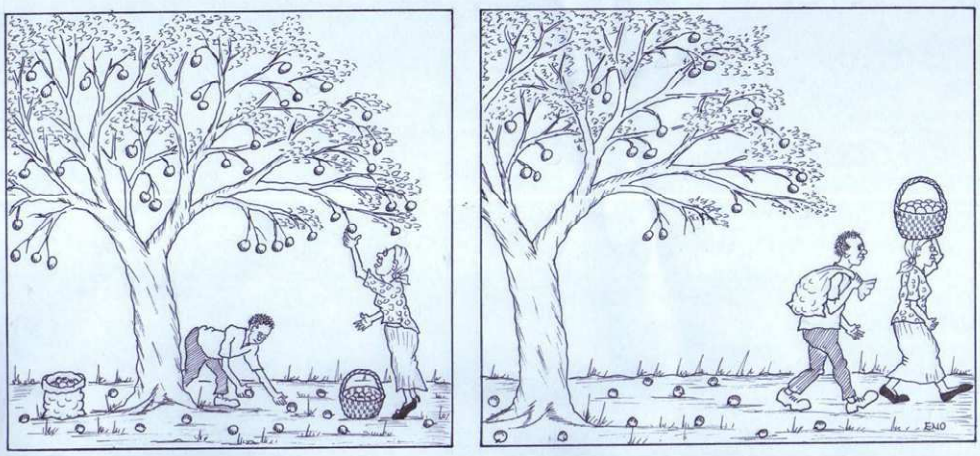


Figure 10: Guidelines for leaf harvesting

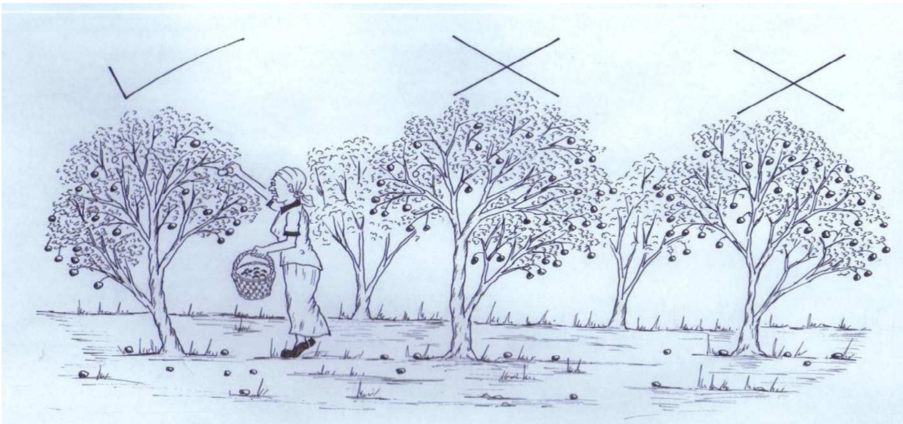
(d) Guidelines for fruit harvesting

Fruits and seeds of an inferior quality can affect species regeneration. So to overcome such regeneration and have quality product, do not collect all good looking, high quality fruits but leave some on the ground so that more plants of good quality can germinate



Do not collect all good looking fruits, but leave some on the ground.

Only collect fruits from some trees and leave others completely



Only collect fruits form some trees and leave others completely.

Figure 11: Guidelines for fruit harvesting

4.3.3. Processing of MAPs

Drying of medicinal and aromatic plants

Drying of medicinal herbs should take place as soon as possible after harvesting; otherwise insects and fungi, which thrive (grow rich) in most conditions, render them unusable. Conventional drying methods such as Open sun drying and Conventional-fuel dryers are not suitable; since they may yield a less quality product and may increase the drying cost or time. Moreover, they may not be reliable and environmentally safe. In most countries, enormous quantities of food losses have resulted from spoilage, contamination, attack by insects/rodents/birds and deterioration during the storage period.

There are number of factors, which are responsible for the post harvest losses, Such as system of harvesting, Processing, storage, Handling and marketing. Drying of product is one of the important post harvest processes and it has enough potential to reduce the post harvest losses, and to prevent spoilage of the product in storage drastically. Moreover, good drying technique can enhance the quality of the product significantly (Garg et al., 2001). Therefore, the drying of medicinal herbs must be accomplished as soon as possible after harvesting, To increase *the quality of the herb and to prevent the expected contamination and losses caused by the infestation of rodents, birds, insects, and fungi which thrive in moist conditions* (Garg et al., 2001; Yahya et al., 2001).

The technical drying process necessitates an enormous amount of thermal and electrical energy. An improvement in the quality of the product to be dried and at the same time a decrease in the drying cost and time are achieved through the utilization of a controlled conventional drying method, which is based on a good utilization of the renewable energy sources. A complete dynamic modeling of the solar thermal subsystem, using the energy balance principle, is developed and the system results are indicated. The results illustrate that the **designed control technique** enables the developed herb dryer system to be in correct and continuous operation during the sunny/cloudy day and night hours (Fargali**,** 2008).

Influence of drying temperature on active ingredients

Generally, high temperature influence essential oil quality and quantity in medicinal and aromatic plants not only during drying; reduction in active ingredients continues during the storage period as well. By increasing the drying temperature from 30 °C to 55 °C, essential oil losses increase by 15 % and the drug color changes from green to gray. Drying temperature usually has an influence on the temperature sensible components of essential oil.

Drying temperature has important effects on the color of medicinal and aromatic plants. Higher temperature could raise dramatic color deteriorations and burning of the product. To withdraw the high amount of moisture from fresh crops, a large amount of energy is needed. The specific drying energy for drying depends on; the material dried, material initial and final moisture content,

Essential oils extraction from medicinal and aromatic plants through distillation

General

Essential oils are the aromatic portions of the plant located within distinctive oil cells, glands, or internal sector canals. In some exceptional cases, essential oils are formed during the extraction of the source plant material. However, some essential oils are formed only as a result of enzymatic reaction. They originate from a single botanical source and can be described as highly concentrated, volatile, and aromatic essence of the plant.

Each essential oil contains hundreds of organic constituents that are responsible for their therapeutic actions and characteristic odor of the source plant material. These components are classified as monoterpenes, sesquiterpernes, aldehydes, esters, alcohols, phynols, ketones, oxides, and coumarins. Essential oils are extracted from various parts of the plant like leaves, roots, wood, bark, seeds/fruits, flowers, buds, branches, twigs, or whole plants (Öztekin & Martinov, 2007). About 65 % of the essential oils produced in the world are obtained from the woody plants that are trees and bushes (Baser, 1999).

According to Oyen & Dung (1999), an essential oil is a mixture of fragrant, volatile components, named after the aromatic plant material of a single type and identify from which it has been derived by a physical process and whose odor it has. The definition indicates that a given essential oil is derived from a single specie or variety. The definition given above states that an essential oil is derived by a physical process, i.e., it has not purposely changed chemically.

The physical process by which the essential oils are obtained may also influence the chemical composition of an essential oil. Essential oils and other flavoring products are isolated from plant material by various extraction techniques such as cold pressing or expression, distillation, solvent extraction, vacuum microwave distillation, maceration, and enfleurage.

The products of extraction are usually termed as concretes, absolutes, pomades, and resinoids, which are not regarded as essential oils. Although the extraction and distillation refer to different isolating techniques, in this text, we use the extractable compounds like essential oils and other flavoring products from the plant materials (medicinal and aromatic plants), mixtures and compounds by chemical, physical, or mechanical ways. Essential oils are generally obtained by various distillation techniques such as water distillation, water and steam distillation, steam distillation, and expression or cold pressing. Among them steam distillation or hydro distillation is the most widely accepted method for the production of essential oils on a commercial scale. Approximately 90 % of the essential oils are produced in this way (oztekin & Martinov, 2007).

Essential oils extraction by distillation

The oldest distillation equipment known dates from the 4th Century AD. It used the familiar process of condensation of vapors on the lid of a cooking pot; the main modification was a rim around the inside of the lid to collect and remove the condensate.

A mixture of water and the material to be distilled was heated to the pot or vat by direct fire, charring occurred, causing some of the compound to decompose. In the 11th century, the Iranian physician, Abu Cina (known in Europe as Avicenna) added a frame to the vat fixed above the level of water, on which the material is to be distilled was placed. In this way, the material came into contact with steam only, and fewer degradation products were formed.

This improvement later led to the development of steam distillation. A final major improvement made in the 12th century was the addition of condenser in which the water could be cooled and condensed rapidly. This greatly improved the efficiency of the distillation process (Oyen & Dung, 1999).

The process of essential oil extraction is an old age essential oil extraction whereby a liquid is separated into components that differ in their boiling points. The distillation technology is relatively simple and adoptable in rural areas. Basically, a simple distillation unit consists of four parts: furnace (heat source), distillation still, condenser, and oil separator.

Although the principle of distillation is the same, practical application of this technique differs depending on the type and physical form of the plant material. Three types of distillation are in practice. These are water distillation (distillation with water), water and steam distillation, and Steam distillation (distillation with steam). The yield, composition, quality, and commercial value of the essential oils are generally affected by the type and efficiency of the distillation unit, as well as the age of the harvested plant material and the ecological conditions where the plant material is cultivated or wild harvested

Water distillation

Water distillation is the oldest and cheapest distillation method, which is simple in design and easy to construct. It is generally used to extract the essential oils of the dried or powdered plant materials, that is, spice powders, ground woody plants like Cinnamon bark as well as some flowers such as rose and orange and Very tough material such as roots, woods, or nuts. During the boiling process, the volatile component, essential oils from special structures inside or at the surface of the plant material, is mostly extracted at temperature just below 100 °C by diffusion mechanism. The extracted volatile constituent is transported along with the steam to the condenser where the mixture of the vapor is cooled and transferred to the liquid phase. This liquid is then taken to the oil separator called the Florentine vessel. Due to density difference, the essential oil is decanted from the water. The remaining distillate, which is the byproduct of the distillation called floral water or hydrosol, can be added to another distillate and redistilled together with it (Öztekin & Martinov, 2007).

The principle of water distillation is to boil and vaporize a suspension of aromatic plant material and water in a vat so that its vapors can be condensed and collected. The essential oil which is immiscible with water is them separated by gravity in a "Florentine flask". The water in the still must be kept in motion to prevent the plant material from clogging together and settling at the bottom of the still. This would result low yield of essential oil, charring of the material and degradation of thermo-instable compounds, resulting in "still odors". Water distillation is still used in traditional field stills, but is mainly used for the distillation of floral material such as flowers and citrus that clog together in other distillation procedures. The main drawback of water distillation system is that large amounts of water have to be heated and the plant material should always be in contact of water which will be used to create steam for distillation (Oyen & Dung, 1999).

To prevent agglomeration of dense plant material and to insure that the plant material is always in contact with the boiling water, the plant material should be stirred throughout the distillation process. As the agglomerated material will settle down, at the bottom of the still, these material will be overheated and thermally degraded, which leads to the formation of off-notes. As the distillation still is directly heated by a furnace, water in this still must always be more than enough to last throughout the distillation process to prevent the overheating and charring of the plant material which leads also to the formation of the offnotes (Lawrence, 1995).

The disadvantages of water distillation system are:

- Energy becomes expensive due to slower process, produces lower quality oil, incomplete release of the essential oil, and
- Skilled labor and large numbers of stills are required as charge has to be less dense (Lawrence, 1995; Vukic et al., 1995). The flow diagram of water distillation process is shown in the following figure.

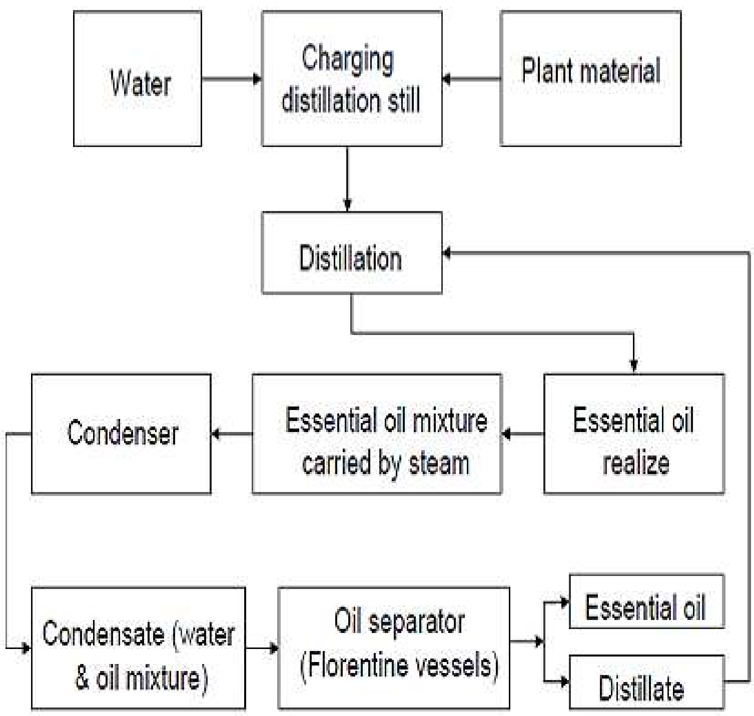


Figure 12: Flow diagram of water distillation Process (source: Adapted from Lawrence, 1995; Oztekin & Martinov, 2007)

Water and steam distillation

Water and steam distillation (also named wet steam distillation) is a method that has characteristics of both water distillation and steam distillation. With this method, a metal grid is placed in the still above the level of water and the plant material is thus avoided. As only the water is heated, the risk of charring and the formation of "still odors" is reduced but the hot walls of the still may cause some damage.

Water and steam distillation are used for many kinds of plant material, e.g., lavender, thyme, and peppermint (Oyen & Dung, 1999). The design of the equipment used is generally very similar to that used in water distillation (Lawrence, 1995). The wet steam can be supplied from the boiling water below the perforated grid at the bottom of the distillation still to provide a uniform steam passage (Vukic et al., 1995). Otherwise, the steam will pass through dominant channels and will be in contact with just some parts of the material. Even if the plant material cannot be in direct contact with the fire source beneath the still, as the walls of the stills are good conductors of heat, unwanted still notes can also be obtained by overheating the plant material.

The wet steam can make the lower plant material resting on the grid quite wet, and slow down the distillation process. It provides time and fuel economy as compared with water distillation system. Higher yields of essential oils with minimum chemical changes are obtained (Öztekin & Martinov, 2007). The flow diagram of water and steam distillation is shown in the following figure.

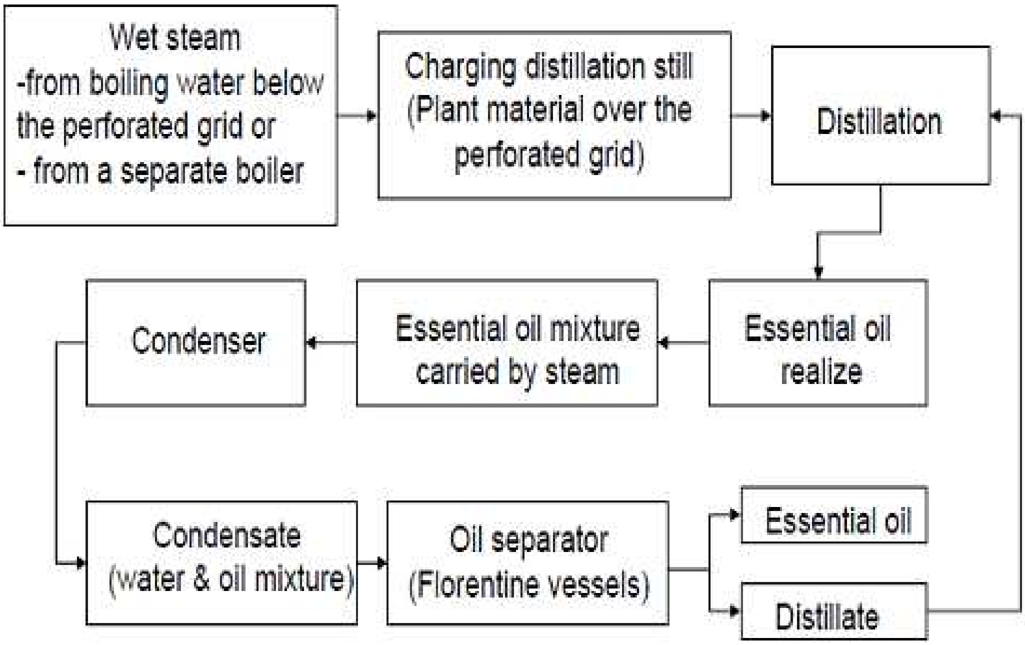


Figure 13: Flow diagram of water and steam distillation process (Source: Adapted from Lawrence, 1995; Oztekin & Martinov, 2007)

Direct steam distillation

In steam distillation (sometimes called "dry steam" distillation), a separate steam generator is attached to the still. As in steam and water distillation, plant material is placed on a grid in the distillation vat, but no water is added. Steam produced in the generator is forced through the material to be distilled. High pressure steam is often used, e.g., steam of 5-10 bars pressure at 150-200 °C.

The duration of the distillation process depends on the steam temperature and the ease with which the essential oil can be removed from the plant material. Plants in which oil is stored in hair glands can be distillated very easily; those in which oil is stored in or below the epidermis require more intensive distillation. The main advantage of steam distillation is that the amount of steam used and its temperature can be readily controlled. As the vat walls do not become hotter than the temperature of the steam,

The risk of charring is minimal. Steam distillation is used for most of the essential oils, except those from delicate flowers. The only precaution necessary when distilling leafy material it is ensured that it is cut not too fine, since this may cause `channeling` resulting in poor distillation yields. Channeling occurs when the plant material becomes too compact. The steam then forces its way through via a few large channels, instead of moving through the entire mass of plant material. Steam distillation is sometimes conducted under reduced pressure, to lower the distillation temperature (Lawrence, 1995).

Steam distillation is the most common method of extracting essential oils on a commercial scale. Approximately 80 to 90 percent of the essential oils are produced in this way. This method is used for the Fresh plant material that has high boiling point like seeds, roots and woods. It is also used for fresh plant such as peppermint and spearmint, oil roses, and chamomile.

This type of distillation plant is similar to other types of distillation plants. The only difference is that there is no water inside the still body during distillation. After the plant material is loaded into the perforated grid, or in a basket or cartridge inside the still body, the saturated or sometimes, overheated, pressurized dry steam that is generated in a separate boiler or a steam generator is injected below the plant material as the steam will flow in the direction of less resistance, the plant material should be uniformly distributed in the still body. The essential oil of the plant material is separated by the process of diffusion while steam passes through the plant material. The steam with a certain contents of essential oil vapors moves through the condenser, usually cooled by running fresh water, where the mixture is condensed. The mixture of condensed water and essential oil is then collected and separated by decantation in Florentine vessel (Öztekin & Martinov, 2007).

The process of steam distillation is more suitable for commercial scale operations. However, steam distillation has several advantages over the previously described variants (Lawrence, 1995; FAO, 1992). It is more energy efficient, cost effective and is the cheapest method of essential oils extraction. It provides better control of the distillation rate. Quality of essential oils produced by this type of distillation units is more consistent and repeatable. There is the possibility of changing working pressure that enables the use of low pressure for high volatile oils and high pressures for low volatiles ones. The rapid distillation is less likely to damage those oils containing reactive compounds like esters. The obstacle for wider use of this type of distillation plant in developing countries and its biggest disadvantage is the high capital expenditure for the equipment.

Many of the demands of the process of steam distillation are often contradictory. According to the existing knowledge the most important demands are to obtain all, or most of the available essential oil from the raw material. To economically justify the process, approximately 85 % of the essential oil in the plant must be obtained. The "dominant channels" can be formed in the still during water and steam, and steam distillation processes. This happens because the plant material gets denser by absorbing water and fresh steam is now not able to move it, and pores in the randomly placed material in the beginning get larger. In this way, only some part of the material is in touch with the steam and obtaining essential oil is far from complete. This can be prevented by using mixers such as auger inside the still body or chopping of the plant material before processing. The risk of losing considerable amount of essential oil exists while chopping the plant material.

As the most efficient of all distillation processes, steam distillation is a very wasteful process. It is always necessary to evaporate relatively high amounts of water to obtain a small quantity of essential oil. Water is never saturated with essential oils vapors. On the other hand, cooling water consumption is high. Cooling water temperature is usually 20 °C at the input and is about 70 °C at the exit from the condenser. The flow rate of this water is, for example, for processing of 300 kg of fresh plant material, up to 2000 kg per hour.

The problem is not just finding the enough rich sources, but affording the price and also the possible micro pollution with water at that temperature. Furthermore, water from the commercial pipe lines, for instance, has to be de-mineralized, prepared for the use in steam generators and for some spiral type condensers (Dachler & Pelzman, 1989). For the improvement of steam distillation system, the techniques like mobile distillation units, turbo distillation, hydro diffusion, continuous steam distillation systems are used (Lawrence, 1995). The flow diagram of direct steam distillation is shown in Fig. below

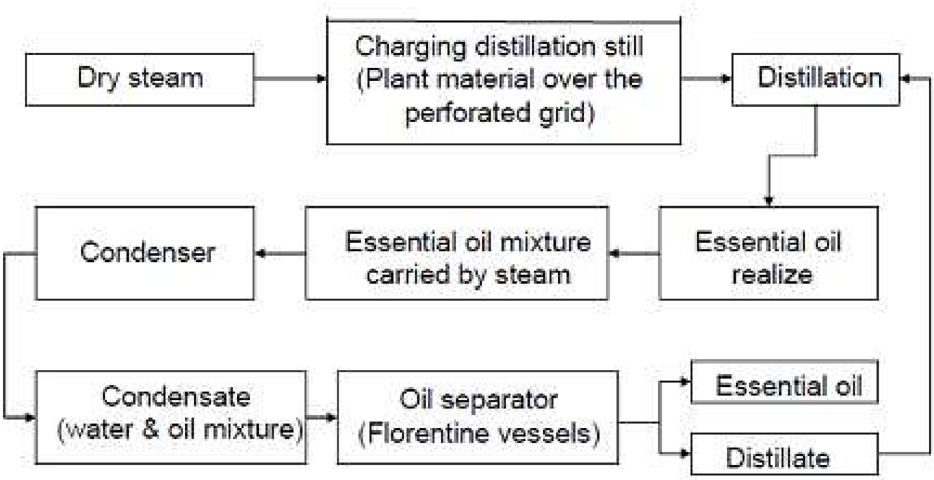


Figure 14: Flow diagram of direct steam distillation process (Source: Adapted from Lawrence, 1995; Oztekin & Martinov, 2007)

Solvent extraction

This extraction method involves passing a solvent through the raw plant material in which the oil then dissolves. The solvent and oil is then separated. The process can take place under atmospheric conditions and at ambient or elevated temperature, in a partial vacuum or in the presence of a gas. Commercial plants use batch, battery or continuous-flow systems, single or multi solvent techniques, and include solvent recovery and oil-refining equipment.

At Small scale or laboratory scale extraction, the processes for the manufacture of concentrated preparations by maceration and percolations are involved in extraction followed by the evaporation of solvents. The two operations are combined in continuous extraction process. The Soxhlet Apparatus on the laboratory scale consists of a flask, a soxhlet extractor and a reflux condenser.

The raw material is usually placed in a thimble made of filter paper and inserted into the wide central tube of the extractor. Alternatively the drug starts imbibitions with the *menstruum and* the bottom outlet for the extract is not blocked. Solvent (hexane) is placed in the flask and brought to its boiling point. Its vapour passes up the larger right hand tube into the upper part of the drug and then to the condenser where it condenses and drops back on to the drug. During its percolation, it extracts the soluble constituents. When the level of the extracts reaches the top level of syphon tube, the whole of the percolates syphon over into the flask. The process is continued until the drug is completely extracted and the extract in the flask is then processed. After the drug is extracted using soxhlex apparatus, the second step is simple distillation that helps to separate mixture of extracted drug and solvents (hexane and ethyl acetate).

Simple distillation enables to fractionate the distillate very accurately; this type of distilling is usually used when redistilling (refining) oils to improve a particular property or concentrate a particular fraction of the oil i.e. rectifying oils In this case, the extracted drug the solvent has volatile character and soon evaporates. Materials for processes of Simple distillation is Heat source, has its own thermometer that helps to read whether the solvents are well separated from the drug. Eg. Solvents of hexane can evaporate with 68 degree centigrade, Water condenser (changes the solvent steam to liquid form), It needs two flask, that one flask contain the mixture of solvent and drug extracted using soxhlex apparatus and the second flask is important to collect the hexane solvent after separated

Absolute flower oils

Absolute flower oils are obtained by maceration, expression, enfleurage and extraction with volatile solvents.

Maceration:

In maceration, the oil cells of the fragrant flowers are ruptured by immersion in a hot fat or oil at 60-70 C which in turn absorbs the essential oils. Fat is separated from spent flowers and reused for absorbing fragrance from the next batch of fresh flowers. The fat retained by flowers is recovered by hydraulic pressing. The resultant perfumed pomade is frequently marketed as such but is often extracted with strong alcohol to yield extracts. These alcoholic absolutes are the absolutes of pomade in marketparlance.

Enfleurage:

Enfleurage is the process of extraction of fragrance by absorbing it from flowers in contact with cold fats. This process is adopted for fragrant flowers of jasmine and tuberose which continue to manifest their characteristic fragrance even in plucked condition. Solvents lack this virtue of arresting the manifested fragrance.

The fats should be saturated and odourless to prevent entrance of fat odours. Refined lard or beef suet are preferred. The fat is thinly layered on both sides of a glass plate supported on a rectangular wooden frame or chassis. Fresh fragrant flowers are lightly layered on the fat coated chasses. Several chasses are placed one above the other sandwiching the flowers between two layers of fat. Spent flowers are removed (defleurage) and fresh charge is made. Reversing of the glass slab is called *patage*. Patage is done several times to obtain maximum perfume absorption. Furrows are created with combs to increase absorption surface. The process of defleurage, fresh charging and patage is continued to obtain fat of the desired perfume strength.

Cold pressing

In 1994 the total world production of vegetable (or fixed) oils amounted to approximately 68 million tons, of which 80% originated from five crops: soybean, oil palm, sunflower, rapeseed, and coconut. Many other plants also produce the vegetable oils of which the major constituents of fatty acids are in most cases sought after for applications outside food production, and including cosmetics and even various industrial applications such as paints and lubricants.

This method is employed when the essential oils are thermosensitive. It is used for isolating essential oils from lemon and orange peels. In expression method there are two processes.

a) The Ecuelle process, where the whole lemons are rolled in hollow vessels covered inside with spikes to puncture oil cells permitting the essential oil to ooze out into a collecting vessel for filtering to obtain clear oil.

b) The sponge process, where the fruit is cut across the shorter axis and the peel separated, steeped in water followed by hand pressing between sponges. The oil soaked sponges are squeezed to release the oil.

Vegetable oils are extracted, mostly cold pressed (as opposed to warm pressed where additional heat is added to the system), and mainly from the whole fruits or their flesh (such as olives), or the seeds (such as safflower and flax), nuts (such as macadamia) or the kernels (such as marula or canhu) of various plants. These oils do not have the volatility of essential oils, and their higher boiling point and imbeddedness in the cellular structure of the plant therefore means that they cannot easily be distilled from the plant materials.

Many of the materials from which vegetable oils are extracted are also primary food crops such as pumpkin and carrots. Extracting the oils from their seeds is another opportunity to add value to the overall crop in increase income potential. There are opportunities to produce culinary oils for the growing natural foods markets throughout the world. The oils expressed from sesame, safflower, pumpkin, carrot and grape seeds, the kernels of apricot and the nuts of hazelnut and walnuts are examples of unique oils experiencing growing demand in these markets. Other than their recognized culinary uses these oils are also finding their way into natural soaps, body and hair oils, detergents and even paints.

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