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Review article

FRANKINCENSE AND MYRRH RESOURCES OF ETHIOPIA: I DISTRIBUTION, PRODUCTION, OPPORTUNITIES FOR DRYLAND DEVELOPMENT AND RESEARCH NEEDS

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ABSTRACT: *Boswellia* and *Commiphora* species are economically and ecologically important plant species found mainly in the horn of Africa particularly in Ethiopia, Somalia and Kenya. They are the source of aromatic gum resins, frankincense and myrrh. Frankincense and myrrh have been valued for their sacred and ceremonial uses as well as in medicinal contexts since several millennia. Still today, they are widely used as raw materials in several industries such as pharmacology, food, beverage, flavouring, liqueurs, cosmetics, detergents, creams and perfumery, paints, adhesive and dye manufacturing. Ethiopia is one of tropical African countries with large potentials of frankincense and myrrh resources and has been known as one of the major producers. Nevertheless, little efforts have been made at national level to explore the vegetation resources that provide these valuable products. Consequently, little is written and known about their distribution, potential production, development opportunities and other relevant issues. This paper presents a review that covers several aspects of these valuable resources including the economic and ecological opportunities they may render for accelerated development and ecological conservation in the vast dry lands of the country.

Key words/phrases: ***Boswellia*, *Commiphora*, ecological opportunity, economic opportunity, oleo-gum resins, olibanum**

INTRODUCTION

Vast areas of land, ca. 51%, in Ethiopia are arid to semiarid (NCSS, 1993; Le Houérou, 1996; Tamerie Hawando, 1997) with marginal or no agricultural potentials. Including the dry sub-humid area, the total dry landmass of the country amounts 860,000 km² (*ca*. 71%) (Tamerie Hawando, 1997). Nevertheless, many of the indigenous trees and shrubs in these vast arid and semi-arid lowlands hold known or potential promise for the production of economically valuable products, principally oleo gum resins such as gum acacia (gum arabic and gum talha), frankincense, myrrh, hinna, and gum karaya (Stiles, 1988; EFAP, 1993; FAO, 1995; Kuchar, 1995; Mulugeta Lemenih *et al*., 2003).

Boswellia and *Commiphora* species are two of the genera in the family Burseraceae that are mainly found in the hot and dry lowlands of north east Africa with a few species in Arabia and India. For thousands of years the aromatic gum resins, frankincense and myrrh, have been harvested from these genera to supply the demands of old civilizations, many faiths and medical demands. Frankincense and myrrh were once regarded as lifeline to spiritual and physical health and considered precious than gold (Groom, 1981; Hillson, 1988; Wilford, 1997). Still today, frankincense and myrrh are widely used in unprocessed form for fragrance in many religious rituals (Coulter, 1987; Farah, 1994; FAO, 1995). Moreover, frankincense and myrrh are phyto-toxically safe raw materials utilized in many of today's industries such as pharmacology and folk medicines (Mielck, 1970; Tyler, 1993; Wichtl and Bisset, 1994; Bruneton, 1995; Budavari, 1996; DAB, 1997; BHP, 1998), food industries (Council of Europe, 1981; Ford *et al*., 1992; FAO, 1995), flavouring, beverage and liqueurs (FAO, 1995), cosmetics, detergents, creams and perfumery (Fragrance Foundation, 1983; Tucker, 1986; Wahab *et al*., 1987; Farah, 1994; FAO, 1995; Leung and Foster, 1996), and in paints, adhesive and dye manufacturing (Krishna-Murthy and Shiva, 1977; FAO, 1995; Anonymous, 2001).

Oleo-gum resins have been articles of great historical commerce in the Horn of Africa in general and Ethiopia in particular (Ahmed, 1982; Coulter, 1987; EFAP, 1993). Today they are among

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the top export articles of Ethiopia where their export alone accounts for about one-half of the total export values (Anonymous, 2001). For instance, in the years 1996/97, 1997/98, and 1998/99 about 1466, 1925 and 1649 tonnes of gum resins were exported from Ethiopia with the total values of US$ 2.5, 2.6 and 2.1 million, respectively (Anonymous, 2001). Ethiopia was the main trader of frankincense and myrrh more than 4000 years ago (Ahmed, 1982), and today Ethiopia and Somalia are the major producers and exporters of frankincense and myrrh in the world market (FAO, 1995; Coulter, 1987; Wahab *et al.*, 1987).

Despite all these facts, little has been done to explore, study and document the vegetation resources that provide these valuable resources in Ethiopia. Thus, information about them is generally scanty (EFAP, 1993; Tilahun Gebremedhin, 1997). Few of the attempts in forest valuations and forestry concerns of the country have focused much on the humid and dry sub-humid forest resources. Comparatively, little attention has been given to the woodland vegetations in the arid lowlands (EFAP, 1993), although the national economic contributions, in terms of export, of the semiarid and arid vegetations far outweigh the forests of the humid and sub-humid combined. One probable reason for the ignorance could be lack of information about them. Similarly, because of the marginalized environmental conditions, arid and semiarid lowlands have often been considered as lands of no economic opportunity (Stiles, 1988). Nevertheless, the arid and semi-arid lands account for more than half of the country's land area (NCSS, 1993; Tamerie Hawando, 1997) and 12% of the population. It is, therefore, urgently compelling to seek for viable strategies that will make the vast arid and semiarid land resources optimally contribute to the national economy as well as buffer the economy of the households living in these marginal arid areas.

This paper presents a review made on some aspects of frankincense and myrrh resources tapped from the arid and semi-arid lowland vegetation resources of Ethiopia. The review is expected to contribute valuable information on the potentials of the arid and semi-arid lowland vegetation assets of the country and the golden opportunity they may provide for the challenges to accelerate economic development in these marginal lands.

WHAT ARE FRANKINCENSE AND MYRRH?

Frankincense and myrrh are resinous plant exudates obtained from certain species of the genera Boswellia and Commiphora, respectively. Both genera belong to the family Bureseraceae. *Boswellia* and *Commiphora* species that yield frankincense and myrrh are tropical genera, which are dominantly found around the Horn of Africa, and some in Arabian Peninsula and India (Wahab *et al.*, 1987; Farah, 1994; FAO, 1995; Ermias Dagne *et al.*, 1997).

The word frankincense is derived from the old French term "france encens", meaning "pure incense" or literally, "free lighting" (Tucker, 1986). Frankincense, incense, olibanum, resin, and aromatic products, are all used to refer to the products of frankincense tree. As the product is odoriferous, it is often referred to as incense in general terms while technically this product is referred to as gum-resin (Farah, 1994). The term olibanum is dominantly used exchangably with frankincense (Farah, 1994; Tilahun Gebremedhin, 1997).

Frankincense is produced and exported by few countries. Somalia and Ethiopia are the major producers and exporters (Wahab *et al.*, 1987; Coulter, 1987; Farah, 1994; FAO, 1995). In India, resinous gum obtained from *Boswellia serrata* is also traded as frankincense under the name Indian olibanum but is graded as an inferior quality olibanum at international market (Farah, 1994; FAO, 1995). The frankincense produced from *Boswellia sacra* species (Somali name 'Moxor') is called Somali type olibanum in the international trade, and the second frankincense from *Boswellia frereana* Birdw species (Somali name 'Yagcar') is known by the name luban lami in Arabia (Farah, 1994). Two types of frankincense are distinguished from Ethiopia: the Ogaden quality and Eritrean/Tigray type. The Eritrean/Tigray type olibanum is the most widely traded frankincense in the world (Farah, 1994), and is the gum-resin obtained from *Boswellia papyrifera* (Del.) Hochst. The Ogaden type is gum-resin type produced in the east and south-eastern parts of the country. This type is known by the name Borena and Ogaden type of olibanum in Ethiopia. The specific source species for these latter types of frankincense are not consistent in the literatures found. However, some of the sources indicated that resins from *B. rivae* (Engl.), *B. ogadensis* (Vollesen) (Somali name 'Gended'), *B. neglecta* (S. moore) (Somali name 'Murufur') and *B. microphylla* (Chior.) (Somali name 'Muqlay') are collected and traded as frankincense in this area (Girmay Fitwi, 2000; Mulugeta Lemenih *et al.*, 2003). Other species that yield resinous products designated as frankincense may also exist in these parts of Ethiopia, and may even include those species known from Somalia, for instance, *B. sacra* (Vollesen, 1989).

Myrrh is sometimes called bdellium or oppoponax, although distinction is often made between the three depending on the source species. Others also divide myrrh as scented/perfumery myrrh (called 'bissabol' or oppoponax) and medicinal myrrh (called 'heerabol') (Thulin and Claeson, 1991). Myrrh (heerabol) is a typical name for the gum obtained from *Commiphora myrrha* (Nees) Engl., and is called true myrrh (FAO, 1995). This is probably the myrrh used dominantly in medical context. Oppoponax/scented myrrh is the name given to the myrrh obtained from *Commiphora guidottii* Chior. (Thulin and Claeson, 1991; Farah, 1994) or *C. erythraea* (Ehrenb.) Engl. or *C. kataf* (FAO, 1995). There are still many *Commiphora* species that yield gums that are sold under the name myrrh or oppoponax such as *Commiphora borannsis* Vollesen, *C. africana* (A. Rich.) Engl., *C. habessinica* (Berg.) Engl. *C. madagascariensis*, *C. kataf*, *C. erythraea* (Ehrenb.) Engl. and others (Groom, 1981; Tucker, 1986; Mulugeta Lemenih *et al*., 2003). It is not clear whether the myrrh obtained from these latter species are used for fragrance, medicinal purpose or for adulteration (FAO, 1995). Nevertheless, the gum-resin obtained from *C. africana* called 'hagar' in Somali is know to be collected and traded for medicinal use in Liban Zone of the Ethiopian Somali National Regional State (ESNRS) (Mulugeta Lemenih *et al*., 2003). Furthermore, oleo-gum resin collected from *C. erythraea* /*C. holtziana*, also called 'hagar' in Somali is exported from Kenya as oppoponax just like bissabol (Provan *et al*., 1987), although it is different from the true scented myrrh produced from *C. guidottii* (Thulin and Claeson, 1991). Myrrh and its various associates obtained from different species of *Commiphora* are technically referred to as gum (Farah, 1994). The word Myrrh assumed to have been derived from the Assyrian word called 'murru' (Tucker, 1986).

In general, the botanical origin of frankincense resins and the name ascribed to their sources has been a subject of much uncertainty and discussion over many years. This is one of the most difficult areas that should be addressed by research in the future. The situation for myrrh and *Commiphora* species, is even much more complex (FAO, 1995). These mix-up of names, lack of proper assortments or mixing gum-resins of different species into a single one in shipments, and unrecorded parallel trades between countries have had their own root consequences in making identification of source species, quality controls and source countries very difficult. The fact that collectors, traders, enterprise owners and officials know very little about the uses to which oleo-gum resins traded are put by the final consumers have its own contribution to the absence of quality concepts (Farah, 1994).

THE GENERA *BOSWELLIA* AND *COMMIPHORA* IN ETHIOPIA

General description

Boswellia and Commiphora belong to the family Burseraceae. This family has 17 genera with estimated 560–600 species (Vollesen, 1989; Gachathi, 1997). This family is widespread in all tropical regions and extending into the subtropics. However, only the two genera, Boswellia and Commiphora with 58 species are known to exist in Ethiopia (Vollesen, 1989). Six of the 58 species belongs to the genus Boswellia and the rest to the genus Commiphora (Vollesen, 1989).

The diagnostic features of the family Burseraceae are that they are trees or shrubs with prominent vertical resin ducts in the bark. The leaves, which are compound, are spirally arranged and crowded at twig-tips. The flowers are rather small and are either solitary or inflorescences usually at the twig-ends, regular with parts in threes to fives, bisexual or more often unisexual, the plants often dioecious. The sepals are fused and are either imbricate or valvate, petals and usually in two whorls. The ovary is superior with three to five carpels and two to five locules. The fruit is usually a drupe, sometimes a capsule. Seeds are without endosperm (Gachathi, 1997).

Botanical description

Genus Boswellia

The genus Boswellia Roxb. Ex Colebr. is composed of 20 or so species extending from Ivory Coast to India and south to N.E. Tanzania and N. Madagascar but most numerous in north east tropical Africa (Kuchar, 1995, Vollesen, 1989, Gachathi, 1997). These are unarmed shrubs or small to medium-sized trees. The outer bark is often peeling in parchmentry flakes, while the inner bark greenish, with watery aromatic resin, which slowly hardens to a resin on exposure; the wood is with milky latex. Leaves are imparipinnate, mostly congested at the end of branches. Flowers are bisexual and are in panicles or racemes. Calyx is 5-lobed. Petals are 5, free, oblong to ovate, and acute. Stamens are 10 and free. Disc is conspicuous, annular, flat or concave. Ovary is trigonous, (2) 3 (4)-locular; style is simple, and stigma is capitate. Fruit is a (2) 3 (4)-locular obtetrahedroid drupe with woody exocarp, dehiscing with the valves dropping and leaving a central (2)3(4)-winged column with the stones attached. Stones are tetrahedroid when young with a thin papery wing formed from outer layer of endocarp, with apical and/ or lateral and/or basal extensions (horns) (Vollesen, 1989; Kuchar, 1995; Gathachi, 1997).

Table 1. Economically valuable frankincense and myrrh producing *Boswellia* and *Commiphora* species found in Ethiopia.

Species	Common name	Location in Ethiopia	Sources
Boswellia sacra Fluckiger	Mohor (Somali)	ESNRS	Groom (1981); Vollesen (1989)
B. neglecta S. Moore	Murufur (Somali)	"	Vollesen (1989), Kuchar (1995) & Mulugeta Lemenih *et al*., (2003)
B. ogadensis Vollesen	Gended (Somali)	"	Vollesen (1989), Mulugeta Lemenih *et al*. (2003), Kuchar (1995)
B. microphylla Chiov.	Muqlay (Somali)	"	Vollesen (1989), Mulugeta Lemenih *et al*. (2003), Kuchar (1995)
B. papyrifera (Del.) Hochst.	Etan (Amharic) (Tigray /Eritrean type)	North and Northwest Ethiopia	Tilahun Gebremedhin (1997), Abeje Eshete (2002), Vollesen (1989)
B. rivae Engl.	Etan (Amharic) (Borena type)	Oromiya/ESNRS	Vollesen (1989), Girmay Fitwi (2000)
Commiphora myrrha (Nees) Engl.	Molmol (Somali)		Mulugeta Lemenih *et al*. (2003), Farah (1994), Vollesen (1989)
C. truncata Engl.	Foah (Somali)		
C. guidotti Chiov.	Hadi (Somali)		Thulin and Claeson (1991)
C. habessinica (Berg) Engl.	-		Tucker (1995), Girmay Fitwi (2000)
C. schimperi (Berg.) Engl.	-		Girmay Fitwi (2000)
C. boranensis Vollesen	Murfur (Somali)		
C. erythraea (Ehrenb.) Engl.	Hagar (Somali)		Thulin and Claeson (1991)
C. africana (A.Rich.) Engl.	Hagar (Somali)		Mulugeta Lemenih *et al*. (2003); Azene Bekele *et al* (1993)
C. ogadensis Chiov.	Murfur (Somli)		Vollesen (1989)

Genus Commiphora

The genus Commiphora *Jacq.* comprises of 150–200 species of which 50–52 species are found in Ethiopia. The genus is a very conspicuous and dominant element in the dry bush lands of NE Africa, and a large number of species are endemic in this area. They are trees or shrubs; branches often terminating in spines; outer bark often papery and peeling, inner bark usually greenish, with resinous–usually aromatic–sap, wood with milky latex. Leaves imparipinnate or 1-3-foliolate (rarely simple), often congested at branch ends. Flowers unisexual and dioecious, usually before the leaves appear or with new leaves, in panicles, cymes, racemes, fascicles or solitary. Calyx 4-lobed. Petals 4, free, linear to elliptic, recurved apically. Stamens (4) 8, didynamous, antisepalous usually the longest, vestigial in female flowers. Disc 4- or 8-lobed or annular, usually glabrous. Ovary 2 (3)-locular; style short; stigma capitate (rarely clavate); ovary absent or vestigial in male flowers. Fruit with a single 1(2)-seeded stone; exocarp fleshy or leathery, splitting into 2 or 4 valves; outer layer of endocarp forming a fleshy pseudaril (Vollesen, 1989; Kuchar, 1995; Gachachi, 1997).

Geographical distribution in Ethiopia

Natural gum and resin producing trees are mainly found in the drier low lying arid to semi-arid lands in Ethiopia at altitudes varying from 200–1500 m above see level. The gum belt runs in a narrow semi-circle around the western, southern and eastern parts of the country close to the borders as well as in Blue Nile gorges on steep rocky slopes or ridges, lava flows or sandy river valleys, and often associated with gypsum out-crops in the southeastern and eastern part of the country (Thulin and Claeson, 1991; Azene Bekele *et al*., 1993; EFAP, 1993; Farah, 1994; Fitchl and Admasu Adi, 1994; Tilahun Gebremedhin, 1997). They are dominantly found in the Afar, Amhara, Beneshangul-Gumuz, Gambella, Oromiya, ESNRS and Tigray (Table 3).

Estimated and actual production of frankincense and myrrh

It is evident that substantial quantities of gum and resins are harvested annually with significant economic importance in Ethiopia. However, little reliable quantitative assessments at country or regional levels have been made. Available estimates, nonetheless, prompt that the total area of woody vegetations with oleo-gum resin producing trees is very large (Girmay Fitwi, 2000; Mulugeta Lemenih *et al.,* 2003). Information obtained from some of the attempts made to provide quantitative estimates at regional level is summarized in Table 2, while the actual national export since 1992 is presented in Table 3. Since no inventory has been carried out on natural gum and resin resources of the country, the information presented here is neither adequate nor accurate. For example, study made in the Liban Zone of the ESNRS alone confirmed that there is a potential production of 2664990.5 quintals of frankincense, and 1862323 quintals of myrrh as well as large quantity of gum arabic and hagar (Mulugeta Lemenih *et al*., 2003). While the other remaining zones of the ESNRS are also expected to have more or less comparable potentials, the estimate given in Table 2 for the whole region of the ESNRS is far lower than that of the Liban Zone alone.

Tapping/Production process

Oleo-gum resins including frankincense and myrrh have been collected and traded from Ethiopia since antiquity. Nevertheless, the production processes such as tapping, resin collections, processing, grading and marketing of the products are little documented. Moreover, no attempts have been made so far to introduce improved production techniques (Azene Bekele *et al*., 1993; EFAP, 1993; Tilahun Gebrmedhin, 1997). Information obtained from few of the studies made in Ethiopia on traditional tapping systems as well as experiences from other gum resin producing countries are presented here.

Generally oleo-gum resins collection is seasonal and most commonly performed during dry seasons (Murthy and Shiva, 1977; Farah, 1994; Tilahun Gebremedhin, 1997; Mulugeta Lemenih *et al*., 2003). Tapping during rainy seasons is not recommended due to washing off of the gum-resins by the rain and consequent gum-resins' quality deteriorations.

Tapping techniques differ from place to place and, hence, there is no one described method considered as standard or satisfactory method. A common practice for frankincense production involves blazing (wounding) trees by shaving off the bark using sharp instruments. In Tigray, the frankincense trees are blazed at one-meter height above the ground. A tree is tapped at three spots of 15–20 cm interval for the first time on each of the four sides or, if the tree is small only on two sides facing east and west. Second tapping is done 20–25 days after the first tapping. The wound from the first tapping is removed and refreshed during the next visit, and a third tapping is repeated after 20–25 days following the second tapping. At this time, as well, refreshment of the older wounds are made by removing barks from the upper edges of the former blaze (wound) and by carving down to 2 cm of the lower edge. Each tree is tapped and wounds refreshed at an interval of 15 days until the onset of the rainy season, with a tree being tapped 8–12 times per year. In Tigray, a tree is let to rest for a period of 3–5 years for wound healing after a year of gum collection from it. An estimated yield of 1–3 kg of frankincense is collected from a tree per year (Tilahun Gebremedhin, 1997).

Wounding is not universal, however. In some areas such as Liban Zone of the ESNRS, for instance, collection is made just on tears that naturally exude. There are no incisions artificially made on frankincense trees (Mulugeta Lemehin *et al*., 2003). While, in Somali, tapping is done by incisions on the body of the frankincense trees where the bark can withstand wounding. The depth of incision depends upon the depth of the resin-bearing ducts of the plants. The initial cut is no more than a scratch. From the small scratches the cuts develop to wider and deeper wounds as the tapping cycle proceed. At the height of the collection season, the average depth of the cuts may measure about 2.5 mm or more and about the size of the palm of a hand (Farah, 1994). Apart from other factors such as the conditions of the plants, the number of tapping usually corresponds to the age of the tree. Some of the fecund and large trees may bear about a hundred wounds at a time, while smaller trees that are being taped for the first time may bear no more than four incisions. Tapping is a simultaneous process that involves collecting the tears and cleansing (refreshing) the wounds by exposing the resin-bearing ducts for further exudation.

Tapping at the right time is very crucial (Farah, 1994). If the trees are not tapped at the right time, the wound may totally heal. Since it takes time to prepare the plants to produce adequate and superior resin, starting the process all over again will cause a great loss. *Commiphora* trees are always less wounded artificially than frankincense (Farah, 1994). This may be due to their abundance compared to the frankincense tree resources.

In India, traditionally, the trees are blazed all around or leaving a little space. In some places of India, 15 cm wide shaving of the bark round the bole at a height of 60 cm above the ground level is done to a depth of about 1.5 cm. After a month of initial shaving, freshening to a width of 1.5 cm over the initial one is made. In other places, a wound of 20–25 cm in width and 0.5 cm in depth is made all-round the tree at a height of 105–120 cm from the ground level. After about a fortnight, the exudates is collected. Simultaneous with the collection, the wound is refreshed a little upward. This operation is repeated weekly till the commencement of monsoon. Each tree is tapped on a 3 years cycle (Murty and Shiva, 1977). Although the yield from a tree varies according to locality, tree size, season and surface of the wound exposed, in drier areas a well grown tree of about 30 cm in diameter yields about 2-2.5 kg gum-resin in a year (Murty and Shiva, 1977).

Table 2. Frankincense and myrrh production potentials in different regions of Ethiopia.

Regional State	Type of oleo-gum resin	Estimated total area coverage (ha)	Estimated potential production (Quintals)	Source
Afar	1. *Gum olibanum*	65,000	1. 2,500	Girmay Fitwi (2000)
	2. Myrrh/*Gum commiphora*		2. 5,000	
Amhara	1. *Gum olibanum* (Tigray type)	604,382	1. 2,000,000	Abeje Eshete (2002)
	2. *Gum Olibanum* (Ogaden type)		2. 11, 923	Anonymous (1997).
Beneshangule	*Gum olibanum*	100,000	55,000	Girmay Fitwi (2000)
ESNRS	1. *Gum olibanum* (Ogaden type)	150,000	25,000	Girmay Fitwi (2000)
	2. Myrrh/*Gum commiphora*		45,000	
Gambella	1. *Gum olibanum*		nd	Girmay Fitwi (2000)
	2. Myrrh/*Gum commiphora*	420,000	nd	
Oromiya	1. *Gum olibanum* (Borena type)	430,000	1. 60,000	Girmay Fitwi (2000)
	2. Myrrh /*Gum commiphora*		2. 15,000	
Tigray	*Gum olibanum* (Tigray type)	940,000	88, 769.5 to 266,308.5	Tilahun Gebremedhin (1997)

nd = no data

Table 3. Actual natural gum production/export by type for the years 1992–1999 in Ethiopia.

Type of Gum	Production/export (Quintals)							
	1992	1993	1994	1995	1996	1997	1998	1999
Tigray/Eriterean Type olibanum	18,004	25,266	30,637	NP	NP	11,923	7,178	14,223
Ogaden type olibanum	317	596	343	478	2,627	58	NP	NP
Borena type olibanum	54	251	1,168	2,005	1,777	106	NP	NP
Myrrh	373	291	968	486	743	1,051	853	NP
Oppoponax	135	33	NP	9	53	147	80	122
Gum acacia	92	269	1,098	1,485	1,130	56	582	36
Total	**18,975**	**26,706**	**34,214**	**4,463**	**6,330**	**13,341**	**8,693**	**15,378**

Source: Girmay Fitwi (2000); NP= no production

An improved tapping technique was devised and experimented in India on *C. wightii* (Bhatt *et al.*, 1989). The method involves tapping using 'Mitchie Golledge Knife, and treatment with 400 mg root feeding of active substance of ethephone (growth regulatory chemical). The result showed enhancement by 22 times oleo-gum resin production over that obtained in the untreated control. The technique was indicated to be inexpensive, safe, requires no specialized skills and can be easily taught to the traditional collectors (Bhatt *et al.*, 1989). The gains from this improved technique include: shorter tapping cuts, reduced tapping frequencies, improved survival of the tapped plants and optimum production.

DEVELOPMENT OPPORTUNITIES FOR ARID AND SEMI-ARID LANDS

General problems of dry lands

As stated above, about 620,000 km² (ca. 51%) of the landmass in Ethiopia is arid to semiarid (Le Houérou, 1996; Tamerie Hawando, 1997). Including the dry sub-humid area, the total dry landmass of the country amounts 860,000 km² (ca. 71%) (Tamerie Hawando, 1997). In about 22% of this landmass, cultivation is not possible even with the early maturing crops (NCSS, 1993; Tamerie Hawando, 1997). In the remaining parts of these drier areas uneven and unpredictable distribution of rainfall has always been a sever constraint for agricultural performance.

Pastoralism, in different forms, has strong tradition in these vast arid and semi-arid areas of the country. Although it is the sensible mode of production in arid and semi-arid environments, pastoralism is not without weak points. First, its low productivity means the pastoral households are limited to subsistent mode of production where little or none is left for local markets (Steen, 1994). Second, it demands extensive area per household, which implies that it can support only a small population. Even at present low population density, the pastoral economy in Ethiopia could not produce all the food a family needs for basic subsistence, that food shortages are often common during normal dry seasons (Farah, 1997). Thirdly, recurring droughts and frequent fodder failures have been threatening the pastoral economy and their overall socio-economic developments. Moreover, the semi-arid and arid lowlands and Rift Valley in Ethiopia have major problems of salinity and alkalinity, where 36% of the country's total land area is indicated to be potentially susceptible to salinity problems (Tamerie Hawando, 1997).

With rising population and livestock sizes, shrinking land resources, advancing desertification as well as gloomy scenarios in connection with global climatic changes, the prognosis for these marginal lands of Ethiopia does not look good at all. Faster interventions are, therefore, imperative to stop and reverse the trend. On the other hand, the question may be how these vast arid and semi-arid lowland resources could be made productive to support people and contribute to the national economy. The woody vegetation resources that are naturally growing in the arid and semiarid lowlands of Ethiopia may provide enormous opportunities for accelerated economic development in these marginal environments (Mulugeta Lemenih *et al*., 2003).

Economic opportunities

The gum and resins from *Boswellia* and *Commiphora* species are most valued products in economic terms. Frankincense and myrrh are few of the export articles in Ethiopia (Table 3). Simultaneously, the economic significances they provide at local level are wide (Farah, 1994; Tilahhun Gebremedhin, 1997; Mulugeta Lemenih *et al*., 2003). Tapping of frankincense and myrrh provides considerable cash income and employment opportunity (Tilahhun Gebremedhin, 1997; Mulugeta Lemenih *et al*., 2003). It has been shown that in Liban Zone of the ESNRS collection and sale of oleo-gum resins provide annually an average of US$ 80.00 income per household (Mulugeta Lemenih *et al*., 2003), an income that was indicated to cover one-third of the annual subsistence of a pastoral household. This contribution from oleo-gum resins was three fold greater than the contribution from arable crops in the area. Similarly, a study made in Tigray revealed that tapping of frankincense provides considerable employment opportunity for the local people (Tilahun Gebremedhin, 1997). This economic incentive provided by the oleo-gum resin extraction has wider implications in the overall socio-economic conditions of households living in arid and semi-arid lowlands. It diversifies their economy and potentially minimizes the risks associated with frequent crop and fodder failures as a result of the recurring droughts.

Generally, the economy of pastoralists and agro-pastoralists in arid and semiarid regions is not able to produce all the food their families need for basic subsistence, and, therefore, food shortages are common even during the normal dry seasons. Consequently, households are forced to consume purchased grains at relatively high prices, while selling their livestock at reduced prices since large livestock is taken to market during the dry seasons. One advantage associated with the vegetation resources in this regard is their ability to produce gum resins only during dry seasons when forage and grains are scarce (Chikamai and Gachathi, 1994), and thus, potentially be used as alternative source of income for dry seasons.

Moreover, frankincense and myrrh are known to have wide pharmacological and industrial uses and potentials (Mulugeta Lemenih and Demel Teketay, 2003), which have not yet been exploited in Ethiopia. If these industries may be introduced they will provide enormous employment for the local people and significant contribution to the national economy as well. In addition, the vegetation resources in these marginal arid lowlands have other several economic roles for the local people. Livestock production, which supplies the major needs of the pastoral families, is heavily dependent on the plant biomass for fodder provision (Kuchar, 1995). Particularly in dry season as well as during droughts, the trees and shrubs are the only source of fodder for the livestock. The family of *Burseraceae* and *Mimosaceae* are known for their provision of nutritious fodder, and virtually all the *Burseraceae* are palatable to livestock particularly in late dry-season (Kuchar, 1988; Farah, 1994). The vegetation and their oleo-gum resins also provide other products and services of local economic importance such as medicine, emergency food, etc. Therefore, accelerated economic development in these marginal arid ecosystems lies in recognizing the potentials that exist in the vegetation assets for the various oleo-gum resin resources and incorporating them in the development strategy.

Ecological significance

Desertification, which is defined as land degradation in arid, semi-arid, and dry sub-humid areas (Le Houérou, 1996), is reported to have threatened about 72% of Ethiopia's landmass (Tamerie Hawando, 1997). On the other hand, arid and semi-arid lands are generally very vulnerable and easily irreversible once degraded (Eden and

Parry, 1996). Many techniques of desertification controls have been in trial in different parts of the World. These methods dominantly involve the redressing of the vegetation covers and control of soil-wind erosion. Although control of the soil-wind erosion that results from vegetation destruction is a first step in desertification control, strategies that combine economics and ecology are needed (Shengyue and Lihua, 2001). Desertification is derived by factors related to the rural economy. Thus, its control needs to relate to the development of the rural economy in order to form an eco-economic model that can be applied for control. Techniques that support the sustainable production system and promote the economies of the rural community to lead to economic and ecological betterment are required (Shengyue and Lihua, 2001).

The gum and resins producing plants are found in the hot and dry arid and semi-arid areas that are prone to desertification. Consequently, they dispose several ecological significances, while possessing huge economic potentials to buffer and improve the economy of the communities living there. These plants have proved useful as windbreaks and shelter belts against desert encroachment and hence desertification, their canopies intercept rain drops while root systems are effective in reducing soil erosion, thereby stabilizing soils (Mugah *et al*., 1997). The non-destructive extraction of oleo-gum resins means, therefore, conservation of the vegetation resources and the protection of the vast marginal arid and semi-arid ecosystems. Consequently, the environmental benefits of these plant resources in the arid and semi-arid regions are significant.

RESEARCH NEEDS

Despite the early recognition, classification and nomenclature of members of the two genera, Boswellia and Commiphora in tropical Africa have remained unstable (Gachathi, 1997). They have been described as taxonomically difficult, frustrating or simply confusing (Vollesen, 1989; Gachathi, 1997). In general several aspects need research. The following are some of the topics. Although it is accepted that frankincense and myrrh are produced from plants of the family Burseraceae and the genera Boswellia and Commiphora, respectively, there are mix-up and clashes of names, which make identification of which species is the real source of which incense and myrrh. The botanical origins of the frankincense and myrrh and the names ascribed to their sources are generally uncertain (Thulin and Claeson, 1991; FAO, 1995). Moreover, little appears to be definitely known on the source country itself (Farah, 1994; FAO, 1995). For instance, while large quantity of the myrrh traded from Somalia is known to originate from east and southeast Ethiopia (Coulter, 1987; Farah, 1994; FAO, 1995), Ethiopia is not often mentioned as a major producer of myrrh as does Somalia in many references (*e.g.,* Thulin and Claeson, 1991). Furthermore, the olibanum in the Middle East markets is said by some sources to come principally from three *Boswellia* species namely *B. carteri* and *B. frereana* in Somalia and *B. sacra* in southern Arabia. However, Thulin and Claeson (1991) concluded that *B. carteri* is simply a variable form of *B. sacra* and should not be afforded a separate species status. Similarly, while Ethiopia is producing frankincense in the east and southeastern part known by the title Ogaden quality the source species are not known. Moreover, it is uncertain whether the Ogaden quality olibanum is of the same quality, lower or higher compared to the Somali Olibanum. Likewise, *Commiphora* species known to yield gum-resins identified as myrrh are numerous and include*: C. myrrha, C. guidottii, C. serrulata, C. erythraea,* etc. Some sources indicate that the true myrrh, for instance, is originated from *C. molmol* (Evans, 1989; Al-Harbi *et al*., 1994), while others indicate the source of the true myrrh to be *C. myrrha* (*e.g.*, FAO, 1995) and still others report that the two species are just synonymous (*e.g.*, Vollesen, 1989; Yen, 1992). In conclusion there are several areas that research has to address related to the subject of frankincense and myrrh producing species and the vegetation resources of Ethiopia. The following is a general outline:

1. One of the most difficult areas of research is to properly describe the taxonomy of the plants that produce frankincense and myrrh.
2. The identification of the various oleo-gum resins collected from these species has always been a problematic area, particularly when it comes to standardizing the chemistry and potent components therein since adulteration is done most of the time or even proper sorting is absent in the areas of origin due to lack of know-how. This might have hampered discoveries of products of much importance. Therefore, sorting individual species or sub-species gum resins and characterizing the chemistry of their gum resins is very essential.

3. Survey of the distribution, densities and production potentials of the existing stands as well as possibilities for improved management and improved production systems such as tapping techniques, including artificial plantations in the natural environment of the resources for sustained productivity is very essential. This will, definitely, open more demand for these renewable and natural products.
4. Detailed studies of potential markets including possibilities for creation of new local industries such as value-adding processing are needed. Local industries could be expanded at least for the already known products from the resources, while looking for further markets of reliable volume, quality requirements, etc.
5. Owing to lack of adequate scientific techniques of tapping and collection procedures, it has become difficult to optimize the utilization and maintain a good quality standard of this indigenous natural product. At present almost all of the gum-resin resources at present are collected from the wild and untended plants by pastoralists, who use crude and haphazard method of incising the main stem by axes. Heavy tapping could injure the cambium and curtails the life span of the tree on account of poor wound-healing. No doubt that research supports in the areas of tapping techniques and production enhancements are very much desired.

These research efforts could contribute greatly to the production as well as economic and ecological utilization of these vast untapped renewable resources for the benefits of the local, national as well as international communities.

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