Journal of Ecosystem & Ecography
ISSN: 2157-7625

Worku and Bantihun, J Ecosys Ecograph 2018, 8:1
DOI: 10.4172/2157-7625.248

Review Article Open Access

Review the Significant of Non Timber Forest Product and *Boswellia papyrifera* Species in Ethiopia

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Abstract

Non-timber forest products (NTFPs) are organic income of deposit and living thing derivation, harvest beginning usual forest, artificial plantation, forested ground, farmlands and trees outer surface forest or domestic. These foodstuffs are very important source of profits, nourishment and nourishment for many forest based community approximately the earth. This revise try to evaluation accessible and easy to get to literatures on position of NTFPs in sustainable forest management including sociological approach, economic approach, ecosystem approach, technological move toward and its associated armed forces (biodiversity maintenance and carbon confiscation). The use of NTFPs has established attention in brightness of their perceived potential to address both poverty reduction and tropical forest conservation. It was not essential that superior management and use scheme has to be set for diversify foodstuffs advantage for the incomplete the people.

Keywords: NTFP; Biodiversity; Species; Conservation

Introduction

Dry lands, which comprise arid, semi-arid, and dry sub-humid eco-regions, cover nearly 75% of the Ethiopian landmass [1]. These are areas where the aridity index is less than 0.65 and noted to suffer from recurrent droughts, crop and fodder failures, and indeed famine is a frequent phenomenon. Despite the notion that the dry land ecosystems appear to hold limited opportunities, most of them in Ethiopia are endowed with native plant species in the genera Acacia, Boswellia, Commiphora, and Stericulia that are known to yield valuable products, and a wide range of socio-economic and ecological benefits [1-3]. *Boswellia papyrifera* (Del.) Hochst is among the key dry land tree species native to Ethiopia and widely known for its non-timber forest product (NTFP), frankincense production. Besides, it has also other numerous environmental and socio-economic benefits. Nevertheless, the population of the species is in critical condition of degradation due to extensive human encroachment and natural factors [4-6]. The prevailing continuing deterioration, in spite of some attempts to preserve it, is partly due to lack of knowledge about the existing resource base and the required management conditions. In this regard, knowledge on the current status of *B. papyrifera* is important so as to search possible restoration or management measures whereby the ever increasing decline could be culminated and the sustainable utilization of the species be enhanced. The rationale of this review is, thus, to present the current status of *B. papyrifera* and suggest possible management measures through making review of the existing literatures.

Boswellia papyrifera and its Uses in Ethiopia

Description and ecological distribution

Boswellia papyrifera (Del.) Hochst belongs to the family Burseraceae, which contains up to 600 species in 17 genera [7]. One of the genera, *Boswellia Roxb* contains about 20 species of unarmed shrubs or small to medium-sized trees. The genus Boswellia is distributed in the dry regions of the tropics [8]. Six species of Boswellia (*B. papyrifera, B. neglecta, B. microphylla, B. ogadensis, B. rivae, and B. pirrotae*) occur in Ethiopia. With the exception of *B. pirrotae*, all Boswellia species known to be found in Ethiopia are currently tapped for gum-olibanum; *Boswellia papyrifera* being the chief source of frankincense produced in Ethiopia [1,9].

B. papyrifera is a deciduous tree that can be as tall as 12 m or more with a rounded crown, thick branches tipped with cluster of leaves. The bark is smooth, whitish to pale-yellow brown, peeling off in large papery pieces/flakes. A slash/cut in the bark looks red-brown and a fragrant milky resin drips out. The leaves are deciduous, large, compound arranged on long stalks with 11 to 29 leaflets, densely hairy below, which are narrowly ovate to oblong, and waved or toothed along the margin. Flowers are sweet scented, which are white to pink, arranged on long red flower stalks, in loose panicles/heads at the end of the thick branchlets. The fruit is a red capsule about 2 cm long, 3-sided with 3 tapered hard seeds inside [10].

In terms of distribution, *B. papyrifera* is found in Ethiopia, Nigeria, Cameron, Central African Republic, Chad, Sudan, Uganda and Eritrea. It mainly occurs in the Sudanian regional center of endemism and the Sahel regional transition zone. The center of geographic distribution of the genus Boswellia is located in north-eastern parts of Africa where more than 75% of its species are endemic to the area [8,11].

In Ethiopia, the distribution of *B. papyrifera* is confined to the dry combretum-terminalia broad-leaved deciduous woodlands of the north, northwest and some of the northern major river gorges [12]. It is widely distributed in Tigray, Gondar, Gojjam, Wellega, Benishangul-Gumuz, and thinly in Wello, Shewa and Afar [2,8,13,14]. Available estimates indicate that about 1.7 million ha of woodlands that hold *B. papyrifera* as their main species composition occur currently in three regional states namely Amhara, Benishangul-Gumuz and Tigray [2]. At present, the species is dominantly found and widely used in Tigray

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Received Janurary 17, 2018; **Accepted** Feburary 01, 2018; **Published** Feburary 08, 2018

Citation: Worku M, Bantihun A (2018) Review the Significant of Non Timber Forest Product and *Boswellia papyrifera* Species in Ethiopia. J Ecosys Ecograph 8: 248. doi: 10.4172/2157-7625.248

(940000 ha according to Tilahun [6] and Amhara (604000 ha according to Abeje [5] regions.

B. papyrifera thrives in marginal/degraded areas such as steep and rocky mountainous areas with shallow soils, low moisture and high temperature conditions. It grows in areas with altitudinal range of 950-1800 m.a.s.l, rainfall ranges from 100-800 mm per annum, and annual temperature of 25°C-40°C [7,10]. Its capacity to successfully establish itself in dry climatic and poor soil conditions makes it one of the best candidate plant species to restore degraded dry lands, and enhance resilience and adaptation of dry land communities to climate change [2].

Important uses of *Boswellia papyrifera* in Ethiopia

Frankincense production: *B. papyrifera* is one of the key dry land tree species with a multiple socio-economic and ecological uses in Africa [6,7,11]. It is widely known for its aromatic resin frankincense production which constitutes one of the important export articles in Ethiopia, Eritrea and Sudan [11,14,15]. Frankincense (gum-olibanum) is the dried, gummy/resinous plant exudate obtained from the stem of Boswellia tree when tapped [3,9].

Based on their origin, three types of frankincense are distinguished in Ethiopia: Tigray type, Ogaden type and Borana type [16]. The Tigray type olibanum is the most widely traded both on local and international market. It is the gum resin obtained from *B. papyrifera* and produced in northern, western and north western parts of the country. Traditionally frankincense from *B. papyrifera* is produced through artificial wounding of the tree using traditional instruments, a process called tapping [17,18].

Tapping involves wounding by removing/shaving small areas of the bark (0.5 to 1.0 cm deep and 4.0 to 8.0 mm wide, starting at 0.5 m from the base of the stem) of the tree using a specially designed tool, called 'Mingaf'. Upon incision, the bark of *B. papyrifera* exudes a white milky liquid (oleo-gum-resin exudes), which later hardens on exposure to air into globular or club shaped droplets or tears, called frankincense [5,12].

Tapping is a cyclic operation where refreshments of the older wounds and moderate widening of the spots are exercised at each subsequent tapping cycles and it continuous until the onset of the rainy season. Thus, a tree could be tapped 8-12 times in a year at an interval of 15 to 25 days starting from September (beginning of the dry season) to early June (before the onset of the rainy season) [5,6].

Collection of frankincense from *B. papyrifera* is normally carried out after 2-3 weeks of each tapping. The dried exudates are easily detached by the collector or harvested by scrapping them off the tree. Estimates of annual frankincense yield per *B. papyrifera* tree vary considerably. For instance, Wubalem et al. [17] reported a range of 6.7-451.4 gram frankincense per tree per year; Wubalem et al. [19] reported a yield at a range of 0.1 and 1.0 kg per tree per year; and Girmay [16] reported an average yield of 0.5 kg per tree per year. Others reported estimates as high as 3.0 kg per tree per year (usually between 1.0 and 3.0 kg) [18].

The variation in frankincense yield per tree is attributed to tree size (Diameter at Breast Heigh (DBH)), site productivity, season and tapping intensity. Generally, bigger DBH trees provide higher yield than trees with smaller DBH; trees in more arid environments also yield more than trees in wetter environments. Similarly, increased tapping intensity increases yield per tree. Incense yield can be doubled or even tripled by increasing tapping spots per tree from 4-12 [12]. However, this has been shown to affect tree vitality and reproductive biology [20]. Too many wounds also result in finer/dusty tear sizes that are less attractive to buyers. Improvements of the traditional tapping practices and strict regulations are thus required to minimize damage to trees and seedlings during incense harvesting and at same time to improve the product quality. Indeed, an optimum tapping intensity need to be adapted to compromise between tear sizes, total frankincense yield and impacts on the tree [17].

Generally, the recommended tapping intensity per tree is a total of 6 spots (3 spots on each east and west sides) for trees of <20 cm DBH, a total of 12 spots (3 spots on the four sides) for trees of medium DBH (20-30 cm) and a total of 16 spots (4 spots on the four sides) for trees >30 cm DBH. Smaller trees should be wounded on few spots with subsequent increase with increasing tree size [9,18].

The other most essential improvement that needs to be made in frankincense production is quality control. Currently, post-harvest handling practices (cleaning, sorting and grading) are practiced with the Tigray type frankincense. Frankincense from *B. papyrifera* is picked manually using locally made collection vessels. The collected frankincense is sorted out manually and graded according to size, color and purity immediately after harvesting. The collected dried tears (exudates) are first seasoned by spreading them out on mats under temporary shades constructed in the field. The seasoned tears are packed in sacks and transported to permanent warehouses where further processing occurs. Further processing at warehouses involves cleaning the frankincense from foreign materials (such as grass, leaves or small stones) [2].

Afterwards, grading is conducted primarily according to their size and color. Generally, there are five grades of frankincense from *B. papyrifera*. Sieves of 6 mm, 4 mm and 2 mm diameter size are used to separate the various sizes of granules. The first three grades consist of white granules but differ in size. Granules >6 mm in diameter are placed in the 1st grade while those between 4 and 6 mm in diameter become 2nd grade, and between 2 and 4 mm in diameter become 3rd grade. The 4th grade consists of granules of brown or black colour of any size. Black or brown colour results from excessive exposure to heat, dust, insect attack and poor handling. The 5th grade comprise of powder with <2 mm diameter mixed with bark. The first three grades are exported while the 4th and 5th grades are sold locally for domestic uses. In all cases, larger and whiter lumps are valued more than smaller, powdered and darker lumps [4,18].

Although cleaning, sorting and grading play considerable role in improving product quality, the current traditional post-harvest handling practice mostly practiced with the Tigray type olibanum has yet a number of shortcomings to ensure the highest product quality. Major problems include: improper storage, seasoning under unclean conditions, use of inappropriate or unclean containers and poor hygienic conditions during sorting and cleaning. This calls for improvement in storage, handling and transportation conditions. Important components of frankincense of *B. papyrifera* are essential oils, which are partly volatile when exposed to the high temperature prevalent in the production areas. Therefore, harvested quantities should be processed as soon as possible and packed in air tight containers and stored under relatively low temperature. Once the products are properly collected, options for value addition must also be explored and when found economically feasible, the options of value added processing need to be pursued [14].

Socio-economic significances: *B. papyrifera* is a very important tree both at local, regional, national and international levels. The species is utilized locally for its various uses which, among others, include: fence, construction and/or household furniture, firewood, livestock feed, bee fodder, medicine (its bark is chewed against stomach disturbances and its incense as insecticide especially for mosquito as a trap), shading purposes, and as light source (as candle). Traditionally, the resins are chewed by lowlanders to prevent or quench thirst and as gum for fixing/binding broken material [4,6,18].

The other main important part of *B. papyrifera* is the resin (gum-olibanum) that is obtained by tapping its stem. Traditionally, the incense is used as burning incense at home and churches mainly for religious ceremonies. In Ethiopia, there are over 15000 churches, which consume approximately 20500 quintals of frankincense per annum, i.e., 1.5 quintal per year per church [6].

In modern times, the incense from *B. papyrifera* is used in perfume and pharmaceutical industries [1,2]. Frankincense is currently providing diverse benefits in the international markets: it is burnt in many churches worldwide and used as oil extract in a number of applications such as modern perfumery, traditional medicine, pharmaceuticals, fumigation powders, fabrication of varnishes, adhesives, painting, and chewing gum industries. It also gives a flavor in food industry, e.g., bakery, milk products, different alcoholic and soft drinks [13,21,22].

As Ethiopia is one of the world's largest producers of frankincense (gum-olibanum), the exploitation of olibanum is one of the top income and employment generation activities in the remotest parts of Ethiopia and therefore a very important source of revenue for the country and the rural people [3]. Frankincense production is labor-intensive and hence serves as a major source of income and employment opportunities for the local communities, foreign currency for the country, raw material for the economic and socio-cultural activities, traditional medicine and others [5].

In Tigray, for example, frankincense production created job opportunities for about 11758-12228 daily laborers in 1994 and 1995 [6]. In western Tigray alone, annually about 7000 seasonal laborers are employed; among which 31% are women. Men are mainly involved in tapping and collecting incense from the forest while women undertake sorting and grading of the same. A tapper can collect about 10.15 quintal of incense per annum and receives a net income of USD 100 to 150 [4]. Women accrue an average income of USD 16 per month [6]. Similarly, about 1300 individuals are employed annually in Amhara, north Gondar part of the year for the collection and processing of frankincense from *B. papyrifera* [5].

Moreover a growing number of investors and permanent workers are involved in the business. For instance, the Ethiopian NGPME (National Gum Processing and Marketing Enterprise), one of the many enterprises involved in frankincense collection, has employed a total man power of 2515 per annum, on average [4].

Besides, frankincense from *B. papyrifera* constitutes one of the export articles providing considerable foreign currency for Ethiopia [15]. It is exported from Ethiopia to the United Arab Emirates (UAE), Poland, Middle East and Asian countries particularly to Japan and China [18]. However, the export market from Ethiopia has been weakened due to inconsistent supply and ambiguity of grades. Only 7728 metric tons of frankincense was exported in the period between 1995 and 1999. The annual frankincense export of the country between 1995 and 1999 is given below (Figure 1).

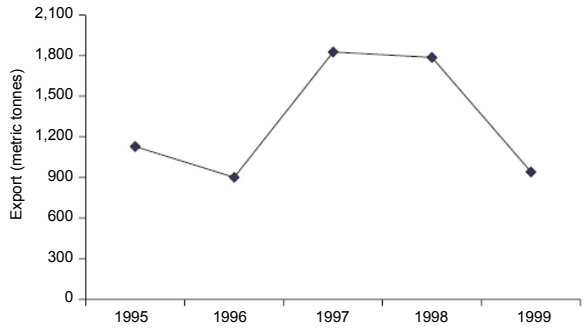

Figure 1: Annual frankincense exports from Ethiopia (in metric tons) between 1995 and 1999 (Source: [18]).

Region	Genus of vegetation	Estimated area
Afar	Commiphora and Acacia	65,000
Amhara	*Boswelia, Commiphora, Acacia* and *Sterculia*	680,000
Benshangul	Boswelia, Commiphora, Acacia and Sterculia	100,000
Gambela	*Commiphora, Acacia* and *Sterculia*	420,000
Oromia	*Boswelia, Commiphora, Acacia* and *Sterculia*	430,000
SNNP	*Boswelia, Commiphora, Acacia* and *Sterculia*	70000
Somalia	*Boswelia, Commiphora, Acacia* and *Sterculia*	150,000-500,000
Tigray	*Boswelia, Commiphora, Acacia* and *Sterculia*	940,000
Total		2855,000-4,355,000

Table 1: Estimated area coverage of vegetations with gum and resin bearing species in Ethiopia by region [1,16].

The annual production volume for the country, for the period 1992-1999, varied between about 248 and 3215 tons [5]. The total amount of oleo-gum resin, including frankincense, exported annually through official routes varied between 147 and 1925 tons, generating foreign currency earnings from 451000 to 2603000 USD (Table 1). Tigray regional state is the richest area of oleo-gum resin producing species, mainly *B. papyrifera* [22]. Gum olibanum from *B. papyrifera* that originate from Tigray region contributes almost two-third (62%) of the total annual production. This is also true in export trade, where it covers the lion share (80%) of the total export of the country [15].

In the current international market, there is ambiguity in determining the demand and supply for frankincense as it is often aggregated into natural gums and resins. This makes the provision of separate statistics for individual gums and resins difficult. Moreover, supplies to domestic consumption are hard to quantify as domestic consumption is mainly for household uses such as fumigation during coffee ceremonies, chat chewing, and dispelling of bad smell and religious rituals. Besides, there exists a great deal of unofficial trading across the borders of producing countries. Hence, enterprises involved in frankincense international trade are recently focusing more on ensuring quality and quantity by offering high price to collectors of export grades [19].

In addition to the export market, substantial amounts of frankincense are sold domestically for religious, social and homestead use. The present supply satisfies less than 15% of the domestic demand [6]. As the supply of frankincense from *B. papyrifera* is not adequate, natural gums from other species are often mixed [2]. Though supplies to domestic consumption are hard to quantify, rough estimates of the domestic consumptions are available based on findings of surveys of household and religious institutions. A household consumes about 5-10 grams of incense per day for the various applications, mainly during

coffee ceremony. The annual average consumption for this purpose is thus estimated at 4500 tones [2]. Domestic sales of frankincense from *B. papyrifera* between 1986 and 1995 are shown below (Figure 2). The domestic sales between 1990 and 1993 were exceptionally low due to the civil war in the main Boswellia growing areas in northern Ethiopia.

Unfortunately, the potential of gum and resins in dry lands development have never been fully utilized until now owing to lack of awareness on the value of these resources at policy level [1]. For instance, much of the frankincense currently comes mainly from Tigray and Amhara regional states [5,6] though the resource is reported to be found in eight regional states of Ethiopia covering an area of about 2.9 million ha [5]. Comparisons of actual production with available potential in the various regions show that the present supplies fall far shorter than the potentials. For instance, the Tigray region, which is the largest producer of gum-resin in the country utilizes lower than a quarter of its potential [19].

Ecological Significances: *B. papyrifera* grows in dry and rocky sites where other tree species often fail. In northern Ethiopia, *B. papyrifera* trees grow on shallow soils (60-80% of the soils are about 20 cm in depth) and in steep slope with an average gradient range of 30-40%. Hence, the species makes economic use of the marginal areas. In those sites, it provides plant cover and produces biomass and hence protects the soil and provides shade. Since growing *B. papyrifera* is economically and socially attractive, it increases the attention for conservation of these degraded sites [18].

Generally, *B. papyrifera* and the other gum and resin bearing species (Acacia, Boswellia and Commiphora species) are characteristically plants of the drier low-lying semi-arid and arid lands (growing in the altitudinal range between 200 and 2000 m.a.s.l). The existence of such vegetation resources under such situation means a lot. According to Lemenih and Kassa [2], they offer better adaptation and mitigation options. The vegetation resources could:

(i) Help to fight against desertification and soil erosion by water and wind;

(ii) Contribute to the conservation and enhancement of biodiversity;

(iii) Improve soil fertility; and

(iv) Provide opportunity for C-sequestration.

Challenges with *Boswellia papyrifera*: an ecological concern

At present, *B. papyrifera* forests are facing several challenges. Several population assessments of *B. papyrifera* in different geographical regions reported that the tree is represented by matured trees, while the smaller sizes (seedlings and saplings) are absent or few, indicating a serious lack of recruitment through natural regeneration and thus an unstable population of the species [23-30].

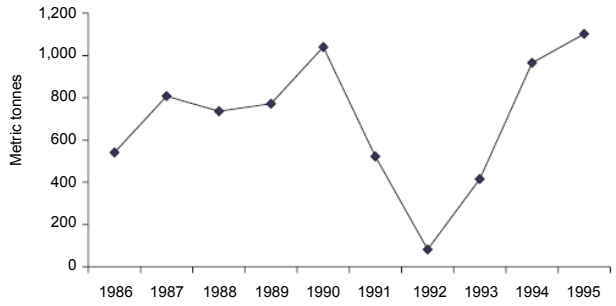

Figure 2: Domestic sales of frankincense from *Boswellia papyrifera* (Source: [7]).

Planting of nursery raised seedlings also demonstrated low establishment successes. The low survival rate can be attributed to the damage from livestock and the lack of silvicultural knowledge of the species, including time of seed collection, nursery practices, choice of appropriate planting sites and post-planting care [11,18]. The major population bottleneck with the species both under natural condition as well as in plantation development is not lack of seeds, poor germinability of seeds nor seedling emergence but high seedling mortality (approximately 100%; [24]. This is raising doubts regarding the long term prospect for a sustained supply of goods and services from the species. Generally, the species is considered as an endangered species and in need of priority for conservation.

The decline in population of *B. papyrifera* in eastern Africa has become an ecological concern [6,11,18]. For instance, in Tigray (northern Ethiopia) more than 177,438 ha of *B. papyrifera* forests have been destroyed in the last 20 years. In the late 1970's, about 510000 ha of land was covered by *B. papyrifera* in Tigray [18] compared to the current figure of 332562 ha [4]. An additional problem is that the remaining population consists of mainly mature trees (e.g. more than 76% of the existing Boswellia trees in northern Ethiopia have a DBH greater than 30 cm) [4], highlighting the problems for natural regeneration. If this trend continues, once the existing old stands are exhausted through natural death and improper utilization, there will not be replacement and the species will likely be extinct. Similarly, in Eritrea, frankincense has dropped from 2000 tons in 1974 to 400 tons in 1998 [11].

Recently, the populations of *B. papyrifera* are declining and its natural regeneration is severely hampered due to a number of anthropogenic and natural factors. Among the direct factors putting heavy pressure on the populations of Boswellia include; extensive farming, over-grazing, intensive and improper tapping practices, increasing forest fires, and biological factors (termite and other insect infestations) [5,6,18,23].

The underlying factors, however, are high population influx mainly through resettlement schemes coupled with weak institutional environment for regulating access and management of the dry forest resources (i.e., lack of properly organized and planned exploitation) [12]. These have led to uncontrolled conversion and unregulated utilization of Boswellia dominated woodlands leading to their widespread degradation and deforestation. Addressing these challenges is, therefore, a major requisite to ensure sustainable production and supply of frankincense.

The Way Forward: Restoration and Conservation Possibilities

B. papyrifera has a great potential both from an economic and from an ecological perspective. However, its population is in a critical condition of degradation due to anthropogenic and natural factors. Therefore, providing protection for regenerated seedlings of *B. papyrifera* should be an immediate task in order to rehabilitate these forests. There are two important demands being made on the *B. papyrifera* bearing degraded forests: speedy environmental rehabilitation and provision of tree products as soon as possible. These are badly needed in Ethiopia.

To reverse the fast depletion of *B. papyrifera* population, some efforts are underway, mainly through area closures and plantations. Recent efforts through the use of closed areas in the dry deciduous forests are positive for environmental rehabilitation [18]. These practices revealed that *B. papyrifera* can easily regenerate from seeds but livestock grazing is detrimental to the growth and survival of its seedlings. Grazing of *B. papyrifera* seedlings result in the total removal of all above ground vegetative parts, which makes survival difficult. Albeit there is a need to address other factors that influence natural regeneration of *B. papyrifera*, the advantages in promoting natural regeneration through closed areas are well recognized [4,11,18,29].

Although the creation of grazing exclosures mitigates soil degradation, releases trees and seedlings from browsing pressure and is therefore essential for forest rehabilitation, seedling mortality during the dry season seriously limits the potential of natural regeneration for Boswellia woodland recovery. Hence, to restore a healthy population structure in exclosures, additional management interventions such as shading to support early seedling survival or planting of large rooted cuttings which are more resistant to drought need to be tested [24]. The seedlings, sprouts and saplings of *B. papyrifera* are sensitive to trampling, browsing and fire; hence need to be protected. Moreover, the protection should also be supported by enrichment planting [25]. In order to promote artificial plantations, however, more silvicultural work remains to be done. In this regard, specific requirements of *B. papyrifera* seedlings in terms of seed collection, nursery life span, planting time and post-planting care need to be investigated [4].

Finally, resin over-exploitation must be avoided to maintain the present high seed vitality in the Boswellia woodlands, particularly in northern Ethiopia [20]. The existing traditional tapping techniques need to be improved in a way to avoid damage to the biology of the *B. papyrifera* trees and to the surrounding seedlings during incense harvesting [18]. Improper tapping of the tree resulted in damage of adult trees through exposing the tree to fire, worm and other attacks [5]. A complete ban of tapping will be unrealistic given the socio-economic conditions attached with the species. However, strict laws and law enforcement mechanisms are necessary in order to minimize damage to trees and seedlings during incense harvesting. Furthermore, developing stronger local institutions in which local community take the lead as well as establishing sustainable market links is essential for successful frankincense based enterprise development at local level. Market links may also create an economic incentive for farmers to responsibly manage the dry forests and sustain the environmental services from woodlands [12].

Conclusion

B. papyrifera is a key dry land species native to Ethiopia and widely known for its NTFP, frankincense. It holds immense actual and potential socio-economic, environmental, traditional and industrial significances. Nevertheless, the population of the species is declining at an alarming rate due to a number of anthropogenic and natural factors. Hence, more efforts in the rehabilitation and management of the species are urgently required. Most of the efforts made to improve the natural stock of the species have limited success due to the lack of knowledge on seed collection, nursery practices and post-planting care. Consequently, further integrated management measures and applied research are required for the sustainable production and rehabilitation of the species. Consequently, for improved management and sustainable production of the species:

a. Improving the regenerative capacity of the species

- Controlling conversion of woodlands and applying intensive management
- Enrichment technology
- Seedling introduction techniques

b. Recommendable utilization

- Improving method and timing of tapping
- Improving methods of harvesting (regulating tapping and harvesting intensity through allowing resting period and/or reducing tapping intensity)
- Product handling, quality control and value added processing

c. Community awareness creation and ensuring community benefits

d. Responsibilities and accountability with effective institutional arrangements.

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