



AN ASSESSMENT OF THE DISTRIBUTION OF NATURAL GROWING BOSWELLIA SPECIES IN WAJIR COUNTY, KENYA

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Abstract: Evidence has shown that *Boswellia*, *Acacia*, *Commiphora* and other dryland trees and shrubs positively contributes to the livelihoods of the local communities and the Kenyan economy through production of gums, resins, oils and other commercial extracts. A study to assess the distribution, inventory and frankincense yield of *Boswellia* species in Wajir County was undertaken. Random line transects were laid down across the major populations from which 165 plots were identified and assessed for GPS coordinates; tree counts and other individual tree parameters. The results revealed that *Boswellia neglecta* and *B. microphylla* were found in the County. Other gums and resins yielding species in the County were *Acacia senegal*, *Commiphora holtziana* and *C. myrrha*. Owing to the harsh climatic conditions, most of the mature gums and resins yielding trees were observed to attain a mean height of between 4 to 7 meters and diameters at breast heights (dbh) of 9 to 15 cm. The yield records show that frankincense production varied widely across various sites, with a mean production estimated at 79.5 g/tree/year through natural exudes thus explaining the low yields of the frankincense production with a county annual production potential of 1,800 MT. Markets for the frankincense and mobilization of resources for collection were the two main drawbacks that warrant further investigation.

Keywords: *Boswellia*, frankincense, inventory, mapping and tree densities.

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INTRODUCTION

The drylands of the world are endowed with a diversity of plant resources such as *Acacias*, *Commiphora*, *Boswellia* and other shrubs with potential for economic development. These species produce gums, resins, oils and other commercial extracts that are in high demand in the world's industries and whose contribution to livelihoods and to national government economy are significant. This study aimed at improving the management of *Boswellia* species and commercialization of frankincense in Kenya. The thrust of the study hinges on the fact that currently, there is little understanding on the

Boswellia spp resource status in the wild as well as issues on sustainable utilization, development and conservation. Frankincense tapping and collection methods were still largely traditional both in techniques where products were being harvested from extensively scattered trees growing naturally in the wild. So far, no significant effort has been made to fill the knowledge gaps on how to improve yield, quality of the product and marketing. Furthermore, the contribution of the frankincense trade in improving the livelihoods of the communities remain unknown and how the trading of the *Boswellia* products fits as an alternative livelihood approach. This study

was therefore structured to address these concerns in Kenya.

The common *Boswellia* species found in Kenya include *Boswellia neglecta*, *B. microphylla* and *B. rivae*. *B. neglecta* was widespread throughout the country with the other two being confined to Wajir and Mandera Counties (Chikamai and Kagombe, 2002) and was the main source of commercial frankincense. It was found in rocky and red loam or clay soils at 220-1,350 m above sea level and 250–600mm rainfall (Beentje, 1994) in *Acacia - commiphora* bushland. Whereas *B. microphylla* could be found in Wajir and Mandera, *B. rivae* had limited distribution in Mandera Counties only. *B. microphylla* could be found growing in mixed stands with *B. neglecta* (Chikamai, 2002). The findings of the review on the state of knowledge on *Boswellia* sp. in Kenya had shown that the area under *Boswellia* species resource remain largely unknown due to lack of information on national assessments involving mapping and inventory on resource status, spread, health and stock densities in the natural areas of distribution as well as their biological and silvicultural development. These include potential for plantation establishment, improvement of germplasm for higher yields, resilience, resistance to diseases and resin tapping techniques.

This study was designed to address some of these concerns to foster improved livelihoods of local communities through increased production and commercialisation of frankincense in the drylands of Kenya. The purpose of this study was to generate data and relevant information on biophysical status of *Boswellia* spp. The specific objectives of the study were; to assess *Boswellia* species resource distribution, inventory and yield of frankincense of individual trees to provide policy recommendations to guide the conservation and domestication of the species.

EXPERIMENTAL

Reconnaissance survey/Study area

A reconnaissance survey was undertaken in Wajir and Garissa Counties to establish the occurrence of *Boswellia* species in the two Counties. However, a higher population of the species was observed in Wajir County, hence leading to a more focussed study in this area.

Wajir County is located in North Eastern Kenya. The county covers an area of 56,685.8 Km². It has a mean annual temperature of 28 °C with rainfall amounts ranging between 250mm and 700mm per annum in different parts of the county. Wajir is located in an arid area prone to drought. It sits at a latitude and longitude of 01°45'00"N and 40°03'00"E respectively (GoK, 2009).

Sampling procedures and assessments

During the tree inventory and mapping exercise, a representative line transect was made across each *Boswellia* spp high density area. Sample plots were then located at random along the line transect, either to the left or right of the transect line, until the total number of plots required for any given site were assessed. A sample plots of 20m by 20m were adopted according to Alder and Synnott (1992) and Philip (1983). In each plot, the following parameters were assessed; the total tree count of all the species occurrence and individual tree measurements of all gums and resins yielding trees (*Boswellia*, *Commiphora* and *Acacia*). The trees were further assessed for the diameter at breast height (dbh), tree height, crown diameter and health index and data recorded in individual plot data sheets. In assessing the plots, a 50m tape and a set of ranging rods were used to mark the transects and plot boundaries and corners.

A four point health index score was used where 1 represented a very healthy tree and 4 as the opposite. The Global Positioning System (GPS) was used to mark sample plots and individual trees and data entered in plot assessment form. The sample plots were located and assessed at each *Boswellia* spp high-density area to develop a GIS based *Boswellia* species distribution map across the County. Table 1, show the distribution of the sample plots in eastern, western, central and northern Wajir County that were covered. The use of GPS was not only necessary but imperative in the assessment of *Boswellia* species and in marking and subsequent location of the sample plots for further assessments.

Table 1: Distribution of Sample plots in Wajir

Region	Locality	Plots sampled
Eastern	Khorof- Harar	12
	Kotulo	20

	Wargadud	12
	Wajir- Bor	6
Western	Griftu	23
Central	Wajir Town	19
Northern	Eldas	20
	Buna	12
	Gurar	15
	Batelo	8
	Tarbaj	18
Grand Total		165

The number of sample plots was determined using the following standard procedure; (i) Pre-sampling of small number of plots in each given site to work out the co-efficient of variation (CV) using the sample standard deviation (SD) and the sample mean (M) thus; $CV = [SD/Mean] \times 100\%$. (ii) Total number of plots to be sampled (N) was computed thus; $N = CV^2/P^2$ where P is the level of significance required, in this case 10% (Alder and Synnott, 1992; Philip, 1983). The parameter used in determining the number of plots to be sampled was the diameter at breast height (dbh). This is because the yields of frankincense is related to the size of the tree with the assumption that large trees generally produce more gums and resins.

Monitoring the yields of frankincense

In order to estimate the potential levels of frankincense production in Wajir County from the tree inventory study, yields of selected *B. neglecta* individual trees were monitored and recorded on weekly basis in appropriate data sheets. A total of 71 trees distributed across the whole County were selected and monitored for yield. This followed the loss of 21 trees at Wargadud through deliberate felling to construct a new feeder road while another 8 trees dried up. For all the selected trees, no inducements were done to enhance the production of frankincense.

Data analysis

Data collected was entered into the computer using Excel spread sheet and analyzed using SPSS computer package. LandSat ETM (digital) satellite images from Global Land Cover Facility were used to generate *Boswellia* distribution maps. The inventory data was analyzed for descriptive statistics and results represented in the form of graph and tables.

RESULTS AND DISCUSSION

Composition of *Boswellia* sp and other gums and resins yielding trees

The composition for *Boswellia* and other gums and resins yielding species (Figure 1) and area coverage was estimated as follows: *Boswellia* spp. (278,040 Ha), *C. holtziana* (110,884 Ha), *C. myrrha* (41,785 Ha), *C. candidula* (188,504 Ha) and *A. senegal* (1,538 Ha).

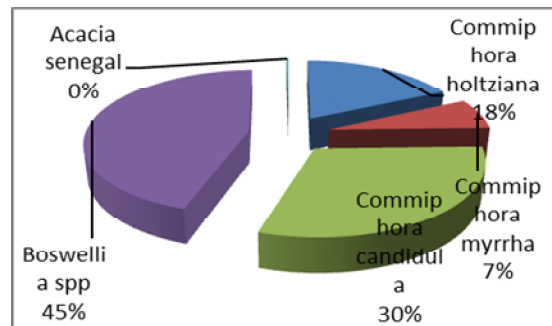


Figure 1: Composition of gums and resins yielding species in Wajir County

The populations of *Boswellia* sp and other gums and resins yielding tree species were characterized by very poor regeneration potential. Ideally, stable populations are characterized by an inverse J shaped curve where young individuals dominate and a gradual reduction of the rest of the larger or older trees. The study established that lack of recruitment and the increasing livestock and human populations negatively influenced the species survival and regeneration, of gums and resins yielding trees. This could be minimized through domestication and protection of *Boswellia* sp plantations (GoK, 2009).

a). Eastern Wajir

The highest densities of *Boswellia* spp were recorded in the eastern parts of Wajir County in four major cluster populations around Khorof-Harar, Kotulo, Wargadud and Wajir-Bor. In Khorof-Harar cluster for example, the densities of *B. neglecta* was found to be about 203 trees per hectare, with a high chance of occurrence (67%) in any randomly chosen plot and trees with mean diameter at ground level (DGL) of 15.4 cm, diameter at breast height (DBH) of 9.6 cm, height (HT) of 3.5 m and crown diameter (CD) 3.5 m. Its densities in the rest of the population clusters in eastern Wajir ranged from 43 to 65 trees per hectare and chance of occurrence ranging from 35% to 50%. *B. neglecta* trees in Wargadud

cluster were found to be twice larger than the rest of the clusters in terms of mean DGL (28 cm), DBH (16.1 cm), HT (6.8 m) and CD (8.5 m).

B. microphylla, *C. holtziana*, *C. myrrha* and *A. senegal* were also represented in the four population clusters of eastern Wajir with their densities varying from 38 to 100 trees per hectare and chance of occurrence of between 17% to 85%. An exceptionally high population of *B. microphylla* could be found around Wajir Bor of about 144 trees per hectare. The population of *B. neglecta* at Khorof-Harar and Kotulo was represented by a wide range of sizes from 1 cm to 20 cm dbh (Figures 2 and 3). However, although their population was dominated by young and mature trees with slightly lower numbers of medium sized trees in Khorof Harar, juvenile trees were lacking in Kotulo (Figure 3).

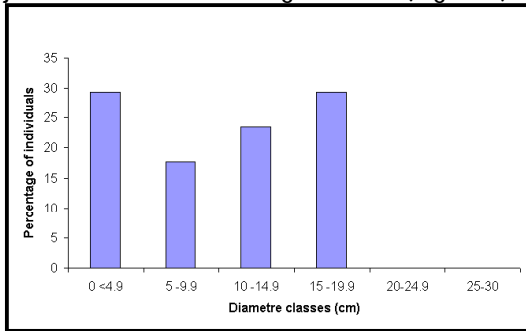


Figure 2: Population structure of *B. neglecta* in Khorof Harar

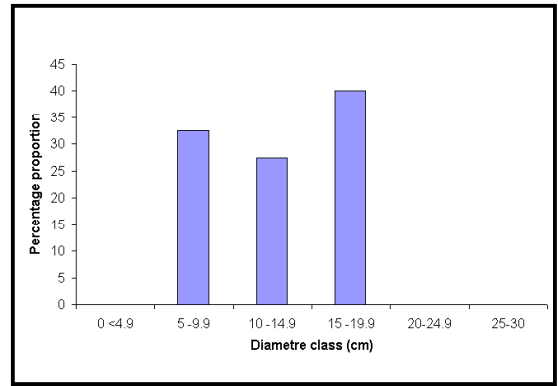


Figure 3: Population structure of *B. neglecta* at Kotulo

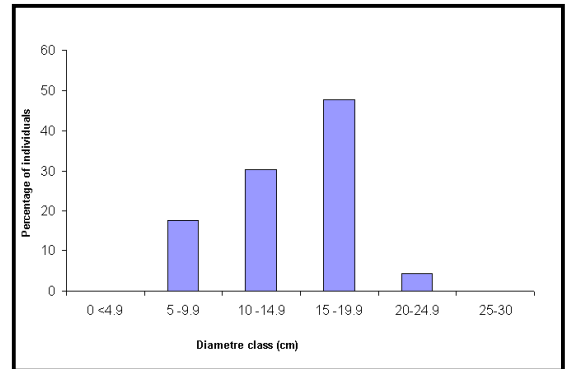


Figure 4: Population structure of *B. neglecta* at Buna

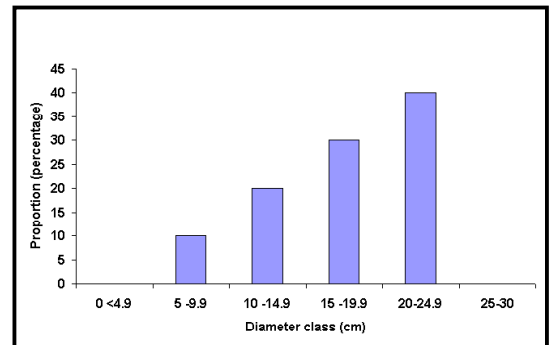


Figure 5: Population structure of *B. microphylla* at Buna

b). Northern Wajir

Northern Wajir had five major population clusters of *B. neglecta* and *B. microphylla* species at Batelo, Buna, Eldas, Gurar and Tarbaj with varying tree densities ranging from 25 (Gurar) to 100 (Batelo) trees per hectare, except Tarbaj with 194 trees per hectare. Northern Wajir is generally drier than eastern Wajir as manifested by the lower chances of occurrence and densities of *Boswellia* spp trees, ranging from 13.3% (Gurar) to 50% (Batelo) but with higher occurrence of 83% at Tarbaj. Eldas and Buna showed moderate densities of *Boswellia* ranging from 25 – 54 trees per hectare and occurrence probabilities of about 30 – 40%. The study results showed that *Boswellia* trees at Buna cluster were generally much larger than the rest of the four clusters in terms of DGL (24.8 cm), DBH (16.9 cm), HT (7 m) and CD (7.8 m). However, *C. holtziana* population were consistently high in the same areas (50–93 trees/ha).

Although most diameter classes of *Boswellia* spp were represented in northern Wajir, most populations were characterized by very poor or complete lack of juvenile and medium sized populations as demonstrated in Buna cluster for *B. neglecta* (Figures 4) and *B. microphylla* (Figure 5). However, the most stable population of *B. microphylla* was observed in Eldas with an increasing representation of mature to juvenile population (Figure 6). *C. holtziana* and *A. senegal* were well represented in all the population clusters in northern Wajir except *C. myrrha* that was only recorded in Eldas cluster.

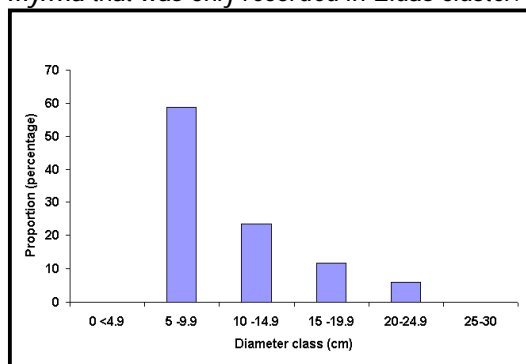


Figure 6: Population structure of *B. microphylla* at Eldas

c). Central and western Wajir

Central parts of Wajir County (around Wajir town) are heavily populated and the human settlements

have had a massive negative impact on the vegetation through felling of trees for fodder, firewood and construction. Around Wajir town there was the absence of *B. microphylla* and *A. senegal* from the populations though there was a high presence of *B. neglecta* (100% probability of occurrence, density of 88 trees/ha) and moderate populations of *C. holtziana* (33%, probability and density of 50 trees/ha). One population cluster of *Boswellia* spp in western Wajir was located around Griftu. The western region was mainly covered by plains and grasslands with little tree cover. Both species of *Boswellia* (probability range of 5% to 30%, densities of 63 to 100 trees/ha) and *Commiphora* (probability range of 5% to 50%, densities of 25 to 68 trees/ha) were represented except *A. senegal*.

Yield of frankincense by Individual Trees

The yield of frankincense varied widely across various sites and seasons, with a mean production estimated at 79.5 g/tree/year through natural exudes (Table 2). However, Wajir County was generally dry at the time of this study resulting in the low yields of the frankincense. The highest yield of frankincense was recorded in Griftu with an estimated mean production of 150 g/tree/year (Table 2) for the year 2006.

Table 2: Individual Tree yields of frankincense

Locality	Year	Khorof Harar	Kotulo	Griftu	Total
Number of marked trees		25	32	14	71
Total production in 3 years (g)	2005	1,251	238	1,550	3,039
	2006	2,512	861	2,491	5,864
	2007	1,451	678	2,281	4,410
Total (g)		5,214	1,777	6,322	13,313
Mean/yr (g)		579	592	21,072	4,438
Yield/tree/yr (g)		70	19	151	80

An overall mean frankincense production of 80g/tree/year as established during the study would mean that a tree population density of 142 trees/ha can produce 11 Kg/ha/yr naturally. The County has the potential to produce 1,800 MT of frankincense per year assuming 60% of the trees are able to yield resin. The recorded yield of frankincense was based on harvesting of natural exudes as opposed to tapping. This study further revealed that the populations of *Boswellia*

species and other gums and resin yielding trees were highly localized within the County as manifested from the high standard deviations of the assessed parameters (HT, DBH, CD and tree densities) indicating that the population patterns were far from uniform even within a defined cluster.

CONCLUSION

Wajir County is endowed with high populations of *Boswellia* species and other gums and resins yielding tree species with huge potential to transform the lives of the local populations through adoption of appropriate collection and marketing strategies as these resources remains largely unexploited. *Boswellia* species constitute about 45% of the gums and resins yielding species in the County with an average yield of 80 grams per tree per year with an estimated potential of 1,800MT for the country. The frankincense collected from each tree was minimal with most collectors relying on natural exudates as opposed to tapping. The factors that contribute to the lack of realization of this potential were poor regeneration potential, unsustainable method of exploiting the resource and lack of ready market for the resource.

It is therefore recommended that:

- Future efforts aimed at mapping and defining the distribution of the population clusters for these species should incorporate other environmental factors such as soil type, elevation, aspect among others.
- The number of random plots should be increased to improve on the sensitivity and accuracy of the clusters.
- Given that the GPS coordinates of each of the marked trees were recorded, a platform for further research on enhanced frankincense production. There is need to initiate the selection of high yielding trees through a well-defined breeding programme aimed at offering a long-term solution in addressing the poor yields of the frankincense. Given that trees in Griftu were generally healthier hence high producers, future selection may focus on this cluster and other similar zone as potential sources of the provenance selection. There is

need to train and create awareness among local communities on the importance of gums and resins aimed at improving the tapping and harvesting methods for maximum production.

- A comparative study should be initiated to compare the yields from natural exudes and tapping of the frankincense hence underlining the importance of intervention through training of collectors.

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