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Occurrence and Distribution of *Commiphora Holtziana* and *C. Myrrha* in Wajir County, Kenya

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Abstract:
This study focused on Commiphora holtziana and C. myrrha that grow in the wild in the drylands of Kenya. The aim of the study was to assess the occurrence and distribution of C. holtziana and C. myrrha species and hagar and myrrh resin yield potential respectively in Wajir County. The research methods included resource mapping using geographical information system and remote sensing techniques and vegetation inventory. The findings showed that the average area under C. holtziana and C. myrrhabetween 2003 and 2011 was 276,222 ha and 61,620 ha respectively not complete, was the area for both species combined? Better desegregate the two species and the periods. The estimated gum resin production potential was 2,200 MT valued at 160 million shillings per year for both gums. Hagar contributed about 70% of the export volume in 2012. Commiphora myrrha was characterised by poor regeneration attributed to over-grazing and poor resin tapping technology among other factors. To enhance local and national benefits from C. holtziana and C. myrrha, it is recommended that national and county governments be involved in sustainable resource management and conservation and investigate on factors influencing the regeneration C. myrrha.

Keywords: *Commphora, mapping, inventory, occurrence and distribution*

1. Introduction

Arid and Semi-Arid Lands (ASALs) occur in the dry sub-humid, semi-arid, arid and hyper-arid lands which make up more than 40% of the earth's land surface and inhabited by 35% of the total population (IFAD, 2000). The drylands are characterized by low (100-600 mm annually), erratic and unpredictable rainfall patterns. In Kenya, the ASALs occupy 89% of the country and are home to about 14 million people, about 75% of the wildlife and approximately 70% of national livestock valued at about 70 billion shillings (Republic of Kenya, 2012). However, there exists potential in the ASALs for exploitation of alternative natural resources which include wood and non-wood forest products, sand, gypsum, precious stones, gravel and building stones. Non-timber forest products (NTFPs) mainly produced in the drylands include fruits, nuts, vegetables, game meat, fodder, medicinal plants, gums, resins, barks and fibres from woodland and riverine forests. The harvesting of NTFPs has a lower impact on the woodland ecosystem than timber and provides socio-economic benefits and ecological services to the local communities (Duong, 2008; Shylajan, & Mythili, 2007).

Among the NTFPs are gum resins in the genus *Commiphora,* which includes 150-200 species that are very conspicuous and dominant in the woodlands and bush lands in the drier parts of the tropical Africa. Most of these species are found around in North Africa, Middle East, India, East Africa, and Madagascar. *Commiphora myrrha* is an indigenous tree species that grows upto 4 m in height; the bark is silvery or whitish to bluish grey that peels in small to large papery flakes, sometimes reticulate fissured on old trunks. The species can be found growing in Acacia-Commiphora woodland and bushland complex. The soils are mainly sandy to loamy overlying limestone or granite, rocky lava hills at 250-1,300 m above sea level. A large number of *Commiphora* species are endemic in this area (Vollesen, 1989). In East Africa the genus Commiphora is represented by about 66 species (Gachathi, 1997). The key Commiphoragum resin is myrrh, produced by *C. myrrha* (Azene, Birnie, & Tengnas, 1993; MacLachlan, Getaneh, & Tafere, 2002; Vollesen, 1989). It is found around Afar, Sidamo, Bale, Hararge in Somalia, Ethiopia, North Eastern Kenya and Arabia (Vollesen, 1989). Numerous other *Commiphora spp*. yield resin and it is not clear to what extent these enter into the market either as adulterants or as inferior type of myrrh.

Wajir County has no gazetted forests and the vegetation is characterised by woody trees and shrubs spread in communal land (GoK, 2009). The economic planners have long believed that the woodland resources are very difficult to quantify and value as they lie outside the conventional forestry management and scientific mechanisms (GoK, 2003). This notion is gradually changing given the huge ecosystems and natural resources potential that act as a secure source of income. The gum myrrh and opoponax potential can significantly contribute to the economic well-being of the local communities and long-term viability of the drylands. Therefore, there is need to understand the local knowledge and natural resource-use systems within the drylands through clear legal property rights for biodiversity conservation (McNeedly, 2006). Sustainable exploitation of the genus Commiphora is constrained by inadequate information on the distribution and production potential (Chikamai & Kagombe, 2002; Girmay, 2000; Mulugeta & Demel, 2003). The general objective of this study was therefore to assess the production potential and contribution of gum hagar and myrrh towards improvement of livelihoods in Wajir County. The specific objectives were to determine the extent of distribution of *C. holtiziana* and *C. myrrha* and assess the hagar and myrrh production potential from their natural habitats in Wajir County.

2. Research Methods

2.1. Study Area

The study was conducted in Wajir County which is known for gum resins production (Chikamai & Kagombe, 2002). Wajir county is located between latitudes 3^0 20’ and 0^0 60’ North and longitudes 39^0 and 41^0 East and covers an area of 56,685.8 Km^2. The County lies within the Sahelian climatic region that is classified as Zone VII (100% Arid) that is characterized by long dry spell and short rain seasons. Wajir experiences an average annual rainfall of 371 mm as recorded in Wajir town weather station. The rainfall amounts ranged between 234 mm and 553 mm per annum over a ten year period from 2001 to 2013 (Wajir Meterological Station, 2014). The average monthly rainfall for the same period indicates that the highest quantity of rainfall is received in the month of April. However, October to December rainfall can sustain modest agriculture. The County borders Mandera to the North and North East, the Republic of Somalia to the East, Garissa to the South and South West, Isiolo and Marsabit to the West and the Republic of Ethiopia to the North West. Wajir County has five livelihood zones: agro-pastoralist, camel pastoralist, cattle pastoralist and mixed animal species pastoralist (Lwevo *et al.*, 2014). Wajir County is sparsely populated with most families living in Manyatas concentrated in/near market centres where bore holes, water reservoirs, food supplies, schools and medical facilities are accessible.

2.2. Estimation of Area under C. holtziana and C. myrrha

To estimate the area under Commiphora species, the research tools included a questionnaire and checklist, observation and photography. The base maps were obtained from the Survey of Kenya and Kenya Data-ILRI. The 1:250,000 topographic maps were digitized and used in identifying and delineating areas with the required resources and in production of updated vegetation maps. Landsat ETM (digital) Satellite images from Global Land Cover Facility for 2003, 2009 and 2011 were acquired, processed, underwent supervised classification and applied in generating resource distribution maps. The satellite images for 2003, 2009 and 2011 were selected based on timeline, population dynamics, stakeholder priorities and incidences of drought. Global Positioning System (GPS) was used to mark the plant’s hot spots for resin production areas that included the position of individual trees. Geographic Information Systems (GIS) techniques were used to map the plant’s cover and perform change detection. The following steps were used in generating and analysing data collected

a) The GPS was used to mark way points for individual trees, boundaries of sample plots and in the production of resource maps using GIS. The GPS coordinates in form of way points were picked for areas where Commiphora species was found growing.
b) These waypoints were later downloaded and changed into shape files. The GPS points were used to aid in development of training sites for classification and ground truthing.
c) The images for the study area were downloaded and joined together (mosaicking) through different geo-referenced Landsat images containing different parts of Wajir County to form a single image for the area of interest.
d) The Wajir County boundary map was used to geo-reference the 2003, 2009 and 2011 Landsat images using Arcmap software.
e) Image for 2003, 2009, and 2011 were registered and independently classified by supervised approach as Tagged Image File Format (TIFF).
f) Preparation of these images for analysis involved geometric registration, clipping area of interest, conversion to IDRISI format, image compositing and histogram equalization.
g) The GIS data was supported by use of photographs and satellite images.
h) The geo-referenced images were clipped to the area of interest.
i) Image classification was carried out using IDRISSI software where supervised classification method was used to classify the images into different thematic classes.
j) A classified image with a legend showing each class was finally produced.
k) Visual approach was then employed to determine image areas with change in classification between the base image 2003 and 2009 image and also a change between 2009 and 2011 images.
l) The geo-referenced topographic map of the area of research was displayed in Arcmap software. From this topographic map new layers were created and digitized, these were rivers, roads and towns.
m) The classified image for 2003, 2009 and 2011 was used to create the distribution maps showing *Commiphora spp.* status in the research area.

n) The final result was a shape file having *Commiphora spp.* polygon only as a layer. To achieve the final result other layers like rivers, roads, research area boundary and towns and GPS points were added to the view.
o) The provisional maps were updated using data from the resource inventory and harmonized to establish the areas covered by each resource (Chikamai, Mbiru, Khamala, & Watai, 2008).
p) *Commiphora species* extent of area coverage was computed by the subtracting the areas for 2011 and 2009 from 2003 *Commiphora spp.* cover and finally 2009 and 2011.

2.3. Estimation of Resource Production Potential

Systematic sampling design using one kilometre transects were cut to run perpendicular to the longest boundary of the woodland in the five study sites. Six sampling plots were laid at an interval of 150m to assess the species occurrence, number, and tree sizes, land use, soil type, tree height and diameter at breast height, GPS points as well as signs of human impacts (Dallmeier, Kabel, & Rice, 1992). Local para-taxonomists were hired to assist in the identification of plants. Sample plots measuring 20m x 20m (Figure 1) were marked along each transect towards the inner side of transect with the first plot being located at least 100m from the borderline. This distance in some cases was adjusted to accommodate the last plot at the woodland edge. The plot details such as GPS location were recorded in the field data sheets. Both scientific and local names of the plants were recorded. Other details recorded in each sample plot were: number and GPS location of gum resins yielding mature trees, number of juvenile trees or saplings and names of the collection centres in the area and names of members of the local community interviewed at the site and their contacts.

- In each 20mx20m (0.04 ha) plot, the total number of all individual trees and shrubs were counted and recorded. The height (HT), crown diameter (CD), diameter at thirty centimeters from the base (D_{30}) and diameter at breast height (DBH) of individual trees with heights of 1.5 m or more were measured using height meter and diameter tape, respectively. For individual trees having heights of less than 1.5 m, their basal diameters and heights were measured using a calliper and calibrated sticks, respectively (Eshete *et al.,* 2005).
- In each subplot of 2mx5m all trees less than 0.35 meters in height (tree saplings) were identified, counted and height of target trees measured and recorded.
- In each of the four plots measuring 0.5 x 2.0 m laid at the four corners of the quadrant, all herbs, grass, tree seedlings were recorded. The herbs and grasses were recorded in percentage.

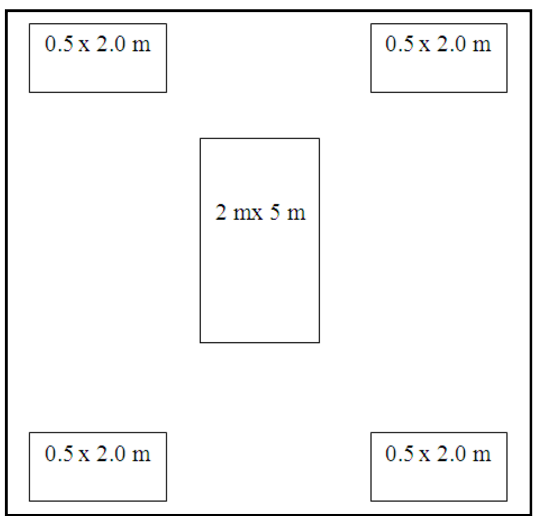

Figure 1: Vegetation inventory plot layout
Source: Ghorbani et al. (2011)

- The individual tree data was used to determine the species composition, frequency of species, relative abundance and distribution, a plant checklist was then compiled.

The vegetation inventory captured the *C. holtziana and C. myrrha* occurrence, frequency and diameter at breast height, height and crown diameter. The vegetation resource inventory was undertaken using the modified-Whittaker plots along a one kilometer transect line. In Modified-Whittaker plot, the shape and spatial distribution of sub-plots in the main plot is changed to overcome the problem of autocorrelation. Within this nested sampling approach, a significantly higher percentage of total species richness was captured compared to other techniques (Ghorbani, Taya, Shokri, & Naseri, 2011; Shackleton, 2000). Vegetation inventory studies are usually associated with a number of errors such as selecting the wrong leaves for study, determining two or more separate species as one and splitting one species into two or more. The other sources of error include having insufficient knowledge of the species' field characteristics, relying on identifications and common names used by local residents and making clerical mistakes (Dalmeier *et al.*, 1992). These errors were minimized through use of one local and one experienced plant taxonomists

Secondary data on *C. holtziana and C. myrrha* gum resin yield estimation was reviewed. *Malmaleys* were interviewed to provide information on tapping and collection of resins during the dry season between January and March and June and September. During the first tapping, 2 mm deep and 4-8 mm wide were shaved; external circular layer of the bark starting at 0.5 m from the base of the stem are made using a hand tool, locally known as 'mingaf' (Girmay, 2000). Three tapping spots are made on each side of the tree though the number could be increased to four in some cases giving a total of six to eight tapping spots being made on each plant depending on its size (Girmay, 2000). Assessment of the extent of spread of gum resin resources and potential yield was based on a method developed by Chikamai *et al.,* (2008). The method is derived as follows; estimated gum resin yielding tree density per given density class; and estimated Density = Mean Density x Area x correction factor. A correction factor was applied to account for the existence of other land use forms such as farmlands, settlements or glades because the mapping units are not homogenous. The following correction factors were adopted for all the resources.

High Density - 75%
Medium Density- 50%
Low Density- 25%
The yield of gum myrrh and opoponax was based on the formula;
Estimated Yield (Kg) = (Number of Stems x Crown Cover x Yield)/1000000
Where; Crown Cover *C. myrrha and C .holtziana* = 25% (Muga, Mutunga, Oriwo & Chikamai, 2015);
Annual individual tree gum Yield = 1.5 Kg (*C. myrrha)* or (*C. holtiziana)*

2.4. Data Analysis

Data was analysed using GIS and SPSS computer packages. The data was analysed for area under resource and gum resin production potential. Hand held GPS was used to pick coordinates of sample points for image training in order to enable supervised classification of the image data. The GIS data was processed and analyzed using the IDRISSI, ArcView 3.2 and ArcMap 9.3 software to generate revised vegetation resource maps within the study area. To determine the population structure of trees and shrubs, all individual trees encountered in the quadrat were grouped into four diameter classes (< 10 cm, 11-15 cm, 16-20 cm and > 20 cm) and four height classes (<*2* cm**,** 2.1- 3.0 m, 31-4.0 m and > 4 m). Density, defined as the number of individuals of a species per unit area, provides a quantitative estimate of the stocking of the species in an area; frequency, defined as the proportion of sample quadrants in which individuals of a species are recorded, reveals the uniformity of the distribution of the species in the study area (Eshete *et al.*, 2005). Population structure which is defined as the distribution of individual trees based on height and diameter classes to provide the frequency profile used to analyse the structure of the population (Eshete *et al.*, 2005). Secondary data was analysed for mean, minimum, maximum and range values of resin yield per individual tree.

3. Results and Discussion

3.1. Occurrence and Distribution of C. holtziana and C. myrrha

Results of a reconnaissance survey of the study area showed the presence of the gum resin producing trees: *C. myrrha* which produces gum myrrh (*Malmal* in Somali language), *C. holtziana* which *p*roduces gum opoponax (*Hagar* in Somali language), *C. ogadensis* that produces *Hagar jerer* which is an adulterant and *Boswellia neglecta* that produces frankincense *(Lubadin* in Somali language). The area under *C. holtziana* was estimated at110,884 ha (2003), 190,186.8 ha (2009) and 527,596.1 ha (2011) while the area under *C. myrrha* was estimated at41,784.7 ha (2003), 74,302.5 ha (2009) and 68,773.5 ha (2011) (Figure 2).

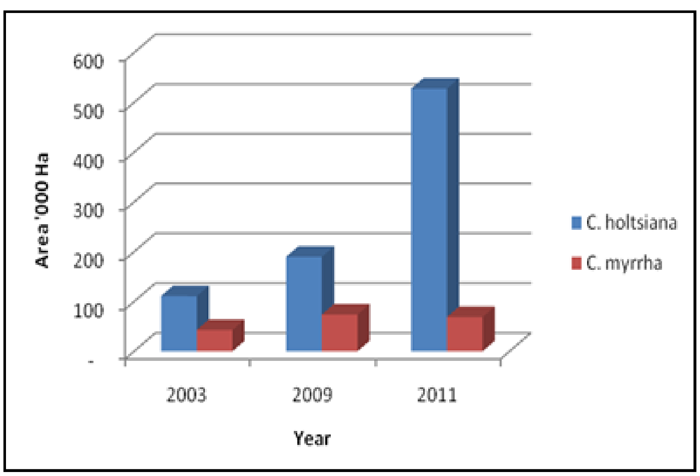

Figure 2: Commiphora holtziana -C. myrrha area coverage
Source: Author, Field data, 2012

Quantification of Commiphora species area cover change between different epochs was achieved. There was a positive change in the area covered by both *C. myrrha* (26,988.8 ha) and *C. holtziana* (416,712.1 ha) between 2003 and 2011. Likewise there was a positive increase in *C. myrrha* (32,517.8 ha) and *C. holtziana* (79,302.8 ha) between 2003 and 2009. For the period 2009 and 2011 there was an increase in *C. holtziana* (337,409.3 ha) but decline in C. myrrha (-5,529 ha). *Commiphora myrrha* increased in 2003 to 2009 period as both the human population was still low but reduced between 2009 to 2011 period due to poor harvesting technologies and upsurge

of refugees who infiltrated the local communities. The key informants attributed the decline of 20% of all the trees harvested to poor tapping techniques as witnessed by the death of *C. myrrha.* Young boys were responsible for poor tapping techniques while looking after goats and sheep around settlements and watering points without knowledge of village elders, chiefs and their assistants. There is a gradual reduction in the vigor of harvested plants, decreased rates of seeds harvested, poor species regeneration and disturbance in woodland plant species composition (Peters, 1996). In the case of non-tapping zones, natural regeneration was largely affected by livestock, especially goats through grazing and trampling and humans through burning (Eshete *et al.*, 2005; Gachathi & Eriksen, 2011). Recurrent droughts as experienced in 1998, 2000, 2004 and 2008 greatly affected gum resins production as many trees died.
The overall damage done to frankincense trees due to improper tapping resulted into the death of over 50% of the trees (Farah, 1994). The key informant further attributes the death of 10% of Malmal trees to other human related activities such as encroachment for agriculture and settlement, over-grazing, use of fire and recurrent drought. The population of *C. holtziana* increased between 2003 and 2011 period, which the key informants attribute to drought tolerance and lack of tapping activities on this species. The other gum resin producing species such as *B. neglecta* increased in cover. The negative ecological impacts associated with gum resins exploitation include gradual reduction in the vigor of harvested plants; suppressed rates of seeds produced and harvested; and low species regeneration (Peters, 1996). The other notable impacts include disturbance in woodland plant species composition, abundance and genetic diversity. Therefore woodland can sustain low intensity extraction rates with a low negative impact on the ecology and biodiversity at the ecosystem and species level (Belicher, Ruiz-Perez, & Achdiawan, 2005). Improved NTFPs production may be enhanced through enrichment planting, low intensity harvesting, rotational use, zonation and protection for higher benefits as compared to the open-access system mainly used in woodlands (Toneen & Wiersum, 2005).

3.2. Gum Myrrh and Opoponax Production Potential

The tree densities ranged between 25-88 trees per hectare in disturbed sites. *Commiphora holtziana* registered an average density of 40 trees per hectare while *C. myrrha* had 31 trees per hectare. The Earlier reported statistics showed that *C. myrrha* is confined to Wajir and Mandera with densities ranging between 83 and 100 trees/ha whereas *C. holtziana* occurs in all the ASAL Counties with densities ranging between 154 and 221 trees/ha (Gachathi & Eriksen 2011). The tree regeneration in Wajir County was mainly influenced by rainfall among other environmental and human factors. The Commiphora species form 42% of the species composition in Wajir County which classified under *Acacia-Boswellia-Commiphora* woodland type of vegetation (Figure 3)

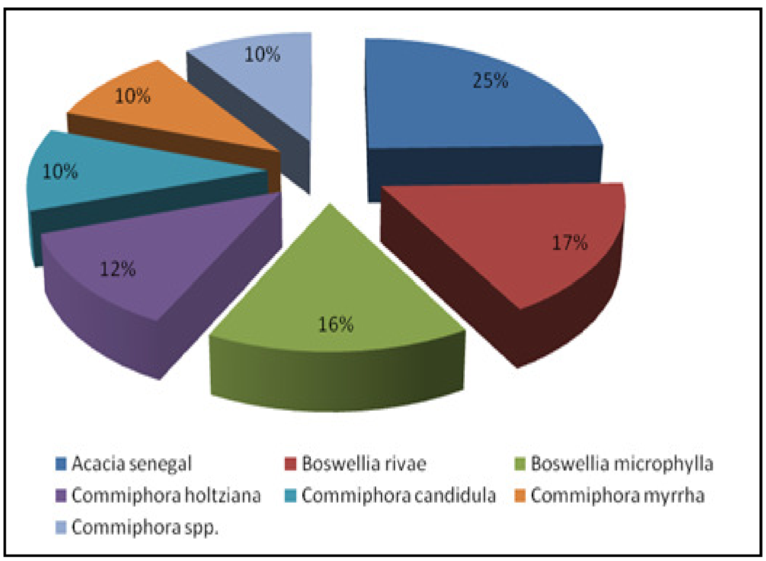

Figure 3: Species composition in Wajir County
Source: Field data, 2012

Most of the *C. myrrha* trees occured in the 11-15 cm diameter class and above 4 m height (Figure 4) with an average DBH of 14.40cm. The absence of the juvenile trees depicts that *C. myrrha* population as unhealthy or exhibits poor regeneration. The results of ANOVA test indicate a significant difference at 95% confidence interval in DBH among the varous diameter classes.

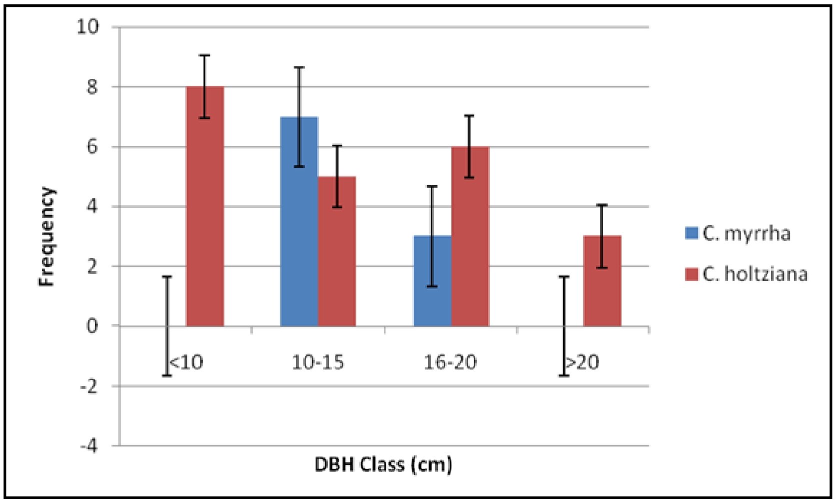

Figure 4: Structure of C. myrrha and C. holtziana based on DBH classes
Source: Field data, 2012

Very few seedlings and saplings were found in all the study sites. The poor regeneration potential was attributed to poor tapping technology and unsustainable grazing practices interfered with normal tree biology thus causing the death of Malmal trees. The frequency reduced in 16 – 20 diameter class. The absence or low regeneration in some diameter distribution classes of *C. myrrha*is explained by poor tapping practices resulting in the death of 30% of all the tapped trees within a period of four years. The human and environmental factors were reported to cause the death of Malmal trees. The use of fire in the management of pasture, overstocking, rainfall failure, and frequent drought were responsible for poor regeneration. Most of the trees registered a height of 3.0 m and above. *Commiphora holtziana* with an average DBH of 13.26cm was evenly distributed in all the diameter classes indicating that the species was healthy due to favourable bio-physical and climatic factors. The structure of *C. holtziana* registered a better distribution (Figure 4) as compared with *C. myrrha* that was skewed due to both human (poor tapping techniques, over grazing among others) and environmental factors (rainfall failure and frequent drought). This can be explained by the presence of significant difference of DBH among the various diameter classes (Table 1).

(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% CI	
					Lower Bound	Upper Bound
<10cm	10-15cm	-5.71*	0.75	0.00	-7.77	-3.66
	16-20cm	-10.65*	0.82	0.00	-12.89	-8.42
	>20	-18.76*	1.12	0.00	-21.82	-15.70
10-15cm	<10cm	5.71*	0.75	0.00	3.66	7.77
	16-20cm	-4.94*	0.70	0.00	-6.83	-3.04
	>20	-13.05*	1.04	0.00	-15.87	-10.23
16-20cm	<10cm	10.65*	0.82	0.00	8.42	12.89
	10-15cm	4.94*	0.70	0.00	3.04	6.83
	>20	-8.11*	1.09	0.00	-11.07	-5.16
>20	<10cm	18.76*	1.12	0.00	15.70	21.82
	10-15cm	13.05*	1.04	0.00	10.23	15.87
	16-20cm	8.11*	1.09	0.00	5.16	11.07

Table 1: Tukey's HSD Multiple Comparisons
*Source: Field data, (2014); * $p<0.01$ and CI = Confidence Interval and Diameter at Breast Height (DBH) is the dependent variable*

The *Malmaleys* reported an average annual yield of 650 grams and 270 grams per tree for Hagar and Malmal respectively during June to September collection. A yield of 6.7 - 451 gram for *B. papyrifera* has been reported for Ethiopia (Mulugeta, 2011). There was significant difference in the reported quantities of Malmal collected per tree between Eldas and Tarbaj at 95% confidence interval and between Wajir East and Tarbaj at 99% Confidence Interval whereas there was significant difference in quantities of Hagar harvested per tree between Wajir east and Tarbaj at 95% Confidence interval (Table 2). Tarbaj is located along the Wajir-Mandera highway making it more accessible thus the difference in quantity harvested. The bio-physical factors that influence the quantity of gum resins harvested per season included amount of rainfall received, type of soils and method of harvesting among others.

Dependent Variable	(I) District	(J) District	Mean Difference (I-J)	Std. Error	Sig.	95% CI Bound	
						Lower	Upper
Average yield per tree (Malmal)	Eldas	Tarbaj	-0.53*	0.21	0.03	-1.03	-0.03
		Wajir East	0.20	0.20	0.56	-0.29	0.69
	Tarbaj	Eldas	0.53*	0.21	0.03	0.03	1.03
		Wajir East	0.73*	0.18	0.00	0.31	1.15
	Wajir East	Eldas	-0.20	0.21	0.60	-0.68	0.29
		Tarbaj	-0.73*	0.18	0.00	-1.15	-0.31
Average yield per tree (Hagar)	Eldas	Tarbaj	-0.08	0.05	0.25	-0.19	0.04
		Wajir East	0.02	0.04	0.84	-0.08	0.12
	Tarbaj	Eldas	0.08	0.05	0.25	-0.04	0.19
		Wajir East	0.10*	0.04	0.05	0.00	0.20
	Wajir East	Eldas	-0.02	0.04	0.84	-0.12	0.08
		Tarbaj	-0.10*	0.04	0.05	-0.20	-0.00

Table 2: Tukey's HSD Multiple Comparison Test
*Source: Field data, (2014); * significant at 95% CI and CI = Confidence Interval.*

All household members in Wajir County irrespective of their age or gender were involved in gum resin collection activities. Most families depended on gum resins collected during the dry season for their livelihood. Gum resin tapping and collection in Wajir County was mainly carried out by *Malmaleys* aged between 15-30 years. Based on the estimated extent of spread, gum resin resources in Wajir County 596,369 hectares, mean stocking densities and a correction factor of 25 % (low density), there are approximately 5,808,956 stems in the county with an estimated gum resin production potential of 2,178,400 Kg with an export value of Kshs. 1 billion in 2012 (Table 3). According to Gachathi & Eriksen (2011), the national annual production estimates are: 2,500,000 Kg for Hagar and 900,000 Kg for myrrh which are an under estimation when compared to the finding in Wajir county.

Species	*C. myrrha*	*C. holtziana*	Total
Product	Myrrh	Opoponax	Both
Stems/ha	31.0	40.0	71.0
Area ('000 ha)	69.0	528.0	596.0
Total stems in Wajir ('000)	533 .0	5,276.0	5,809 .0
Unit Price (Ksh/ Kg)	550 .0	450.0	500 .0
Gum yield (MT/Yr)	199.9	1978.5	2,178.4
Export value ('000 Ksh)	109,930	890,318	1,000,249

Table 3: Potential Gum Resin Production in Wajir County
Source: Field data, 2014

4. Conclusion and Recommendations

The area under *C. myrrha* and *C. holtziana* was influenced by bio-physical and human related factors such as unsustainable tapping techniques, overgrazing, encroachment for agriculture and settlement, use of fire in pasture management and recurrent drought. The population of C. myrrha was adversely affected by poor tapping techniques. There exists an exploited gum resins production potential in Wajir County. The following recommendations were made:

- The use of Landsat imagery is limited by resolution capacity, future research should adopt the application of high resolution imagery such as IKONOS to improve on the accuracy of data capture, analysis, interpretation and decision making.
- Identify degraded sites for rehabilitation through enrichment planting or re-afforestation using priority gum resin yielding tree species.
- Investigate factors that contribute to poor regeneration potential of *C. myrrha* for enhanced conservation

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