

Socio – Economic Benefits and the Associated Environmental Degradation Effects of *Osyris lanceolata* (Hochst & Steudel) Utilization in Kitui County, Kenya

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Abstract: The aim of this study was to assess the utilization and socio-economic benefits of *Osyris lanceolata* (The East African Sandalwood) in Kitui County, Kenya. Data was collected using questionnaires and analysed using SPSS version 20. A total of 120 respondents were interviewed. The results revealed that 78% of the respondents were aware of existence of *O. lanceolata* plants in their region. From these respondents there were two main uses of *O. lanceolata* wood products which included; medicinal and perfumery oil production. The main purpose of harvesting *O. lanceolata* was mainly for commercial use (44.2%), with little use for domestic purposes (16.7%). The major beneficiaries of *O. lanceolata* business were the manufacturers reported by 45% of the respondents, followed by middlemen as reported by 30% of the respondents. The least beneficiaries were the harvesters from the wild and the transporters reported by 17.5% and 5.8% of the respondents respectively. Majority of the respondents (51.7%) reported that the main customers for *O. lanceolata* were the pharmaceutical companies followed by 29.2% who reported that it was perfume and cosmetic companies. There was significant Pearson correlation between socio-economic benefits ($r=0.781$, $P < 0.01$), usage knowledge ($r=0.744$, $P < 0.01$) and distribution ($r=0.666$ $P < 0.01$), with the harvesting trends of *O. lanceolata* from the wild. The study concluded that socio-economic benefits associated with *O. lanceolata* are contributing to its over-exploitation from the wild, thus calling for multi-faceted interventions to minimize loss of this invaluable plant species from the wild.

Keywords: High value multipurpose plants, livelihoods, Conservation

Introduction

Osyris lanceolata (Hochst & Steudel) (The East African Sandalwood) is a predominantly dry land shrub / tree species with Kenya as one of its major range states and especially in Kitui county and other arid and semi-arid areas. The species has also been documented to occur in Baringo, Narok, and Bomet counties among others. The tree is locally known as, *Munyungamai*, *Ndonga* or *Kithawa* in Kikamba, *Msandali* / *Mtiwa marashi* (Swahili), *Muthithi* (Kikuyu), *Mberegesa* (Chagga), *Olseyeayyesi* (Maasai). Sandalwoods are

also indigenous to India, Nepal, Bangladesh and Sri Lanka amongst other Indo – pacific Islands (Orwa *et al.*, 2009). In Kitui County, the tree has been recorded to grow in the central ridges, and on Mutonguni, Kyawea and Endau Hills (Kamondo *et al.*, 2014).

O. lanceolate is an evergreen shrub in the family Santalaceae. It is a semi – parasitic shrub or small tree growing to a height of up to six meters. The species is dioecious with a given tree being either male or female. It is multi-stemmed with dark-brown to blackish bark. The species is evergreen with many drooping small branches with bluish to yellow-green, sharply pointed leaves. Sandalwood is a semi-parasite with its roots attaching to roots of host plants from which they absorb nutrients. The tree occurs on rocky ridges, mountain slopes and the margins of dry forests and in evergreen bush land, in grassland and in thickets. The tree grows at an altitude of between 900 – 2550m above sea level. *Osyris* belongs to the semi – parasitic plant family Santalaceae (the sandalwood family) and its roots will always be found associating with those of host plants (Mathenge *et al.*, 2005). *O. lanceolata* is associated with other species such as *Harrisonia abyssinica*, *Euclea divinivorum*, *Lantana camara*, *Cajanus cajan*, *Rhus natalensis*, *Rhus vulgaris*, *Maytenus acuminata*, *Carrisa edulis*, *Croton megalorcapus*, *Acacia kirkii*, *Grewia similis* and *Dodonaea viscosa* amongst others (Kamondo *et al.*, 2014).

The East African sandalwood is among the sandalwoods known for producing fragrance-scented wood and a world-famous essential oil used in various cosmetics and fragrance industries and has gained popularity also in medicine industries (Dwivedi *et al.*, 1999).

Traditionally, the tree has different uses among different people in Kenya, including making of red dye, smoking milk containers, healing wounds and treating stomach ache, tonsils, diarrhoea, ulcers, snakebite and rashes. The demand for sandalwood has by far outstripped its supply (Krotz *et al.*, 1994).

However, the nature of exploitation of *O. lanceolate* in Kitui County raises concern on its survival in the wild as it involves uprooting of the whole tree / shrub. The mode and scale of harvesting has made the tree to be locally endangered which threatens not only the survival of the species, but also the sustainability of the trade in the species products. *O. lanceolata* is harvested in the wild by uprooting the whole tree including its roots because the essential oil concentration is higher in the roots than the trunk (Mukonyi *et al.* 2011). Under normal conditions, young trees grow slowly, only gradually developing a core of heartwood. It is reported that the harvesting methods used are highly destructive since the whole plant needs to be uprooted to get the roots, leading to a serious depletion of its populations. Unfortunately, while the resource base is declining, the markets of sandalwood oil and products have been rising (Kamondo *et al.*, 2014).

The aim of this study was therefore to assess the utilization and socio – economic benefits of *O. lanceolata* and the associated environmental degradation impacts in Kitui County.

Materials and Methods

Description of the study area

The study was carried out in Kitui County which is one of the 47 counties in the country located about 160 km east of Nairobi City. It is the sixth largest county in the country, covering an area of 30,496.4 km² including 6,369 km² occupied by Tsavo East National Park and Mwingi North Reserve. The county shares its borders with seven other counties namely Machakos and Makueni to the west, Tana River to the east and south – east, Taita Taveta to the south, Embu to the north – west and Tharaka – Nithi and Meru to the north. It is located between latitudes 0⁰10' and 3⁰ south and longitudes 37⁰ and 39⁰ East. (GoK, 2013).

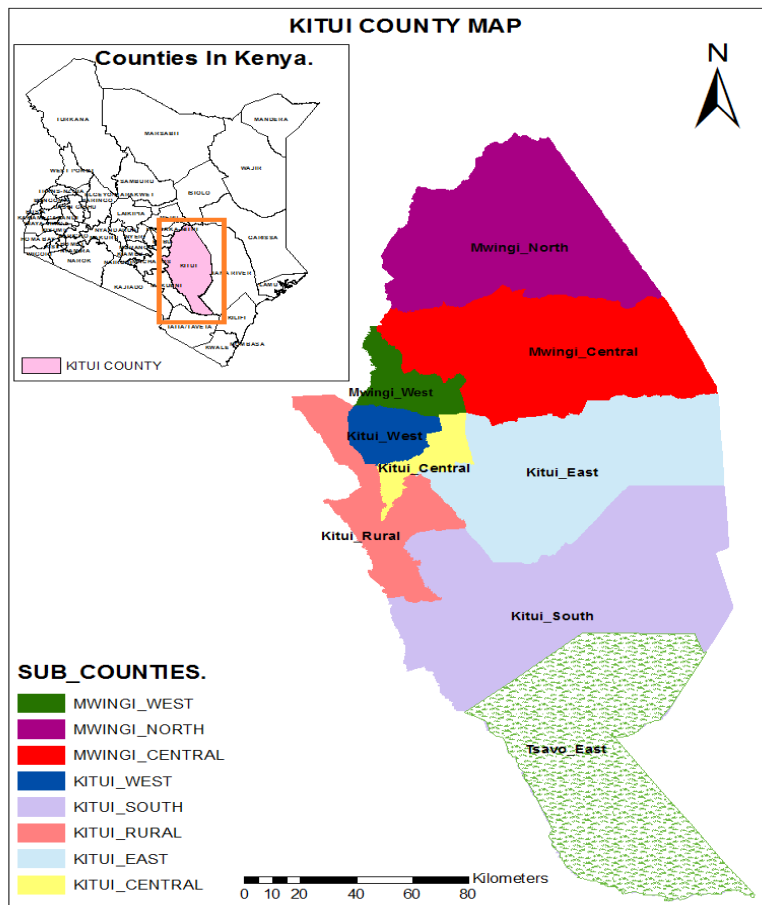


Figure 1: Position of Kitui County in Kenya

The study was carried out in four sub – counties of Kitui County namely Kitui South, Kitui East, Kitui West and Kitui Central. The general study area lies within Kitui County ranges and hills.

Table 1: Details of location of the survey areas

S/No	Sub-County	Location	Sub-location
1	Kitui East	Endau	Ndetani Kathua Kinanie Katumbi
2	Kitui South	Mutomo	Mwala Kitoo Kandai Kawetu
3	Kitui West	Mutonguni	Kangondi Mithini Mutonguni Musengo
4	Kitui Central	Mulango	Wikililye Kyangunga Wii Kyambiti

Data collection

Cluster sampling was used to select the sub – counties based on agro – ecological zones. Purposive sampling was used to select locations and sub – locations in each sub – county (Ranjit, 2011). Open and closed – ended household questionnaires, key informant questionnaires and Focused Group Discussions were used to gather information from the community and local experts working in Kitui County (Mugenda, 2011). Data was analysed for four sub - counties, namely Kitui Central, Kitui West, Kitui East and Kitui South. The respondents included the general community, local administrators (chiefs and their assistants) and herbalists considered as ethno- practitioners in this study. A total of 120 questionnaires were administered and filled in the field. In addition, a total of key informant 20 questionnaires were also administered to government departments and non-governmental organizations in the study area. The Geographical Information System (GIS) was used to analyse GPS data collected during the field exercise.

Data analysis

Data collected in the field was keyed into Statistical Package for Social Sciences (SPSS) version 20.0. Qualitative data generated from the open-ended research tools were organized into themes and patterns based on the study objectives and questions (Orodho, 2008). The organization of database into map layers provided rapid access to data elements required for geographic analysis. Tables, maps, plates and graphs were used to describe and summarize the data while the inferential statistics used for this study included Correlations, Model summary, Chi – square, ANOVA, multiple regression and coefficients. As part of the analysis, Pearson’s Correlation Analysis was also done on the independent and the dependent variables.

Results

On average, (55.4%) of the respondents were males while 44.6% were females. At least 40% of the respondents were 30 – 39 years of age. This was followed by 40 -49 years with 30% respondents. Those above 50 years were 20%. The least were those below 30 years with 16.7%. On the education level of respondents, it was revealed that 46.7% of them had primary education as their highest level of education, followed by 23.3% with secondary education and 19.2% with no education at all. There were however some respondents with college and university education at 5.8% and 3.3% respectively.

The logistic regression analysis on socio – economic factors was found significant ($p < 0.05$) in influencing the *O. lanceolata* utilization in the study areas: gender ($p = 0.017$); level of education ($p = 0.042$), and distribution of *O. lanceolata* ($p = 0.038$). Other factors that were found insignificant ($p > 0.05$) in influencing the *O. lanceolata* utilization in the study area were age ($p = 0.760$), marital status ($p = 0.0821$) and religion ($p = 0.0673$). There was a significant Pearson correlation between gender ($r = 0.638$, $p < 0.01$), level of education ($r = 0.728$, $p < 0.01$) and household income sources ($r = 0.762$, $p < 0.01$), with the harvesting and utilization trends of *O. lanceolata* from the wild.

Table 2: Demographic information of the respondents

Research Parameters		Kitui West	Kitui East	Kitui Central	Kitui South	Mean F (%)	Std. deviation
N=120		F (%) n=30	F (%) n= 28	F (%) n=33	F (%) n=29	n=30	
Gender	Male	16(53.3)	11(39.3)	22(66.7)	17(58.6)	17(55.4)	0.617
	Female	14(46.7)	10(35.7)	18(54.5)	14(41.6)	13(44.6)	0.69
Age	Below 30	7(23.3)	3(10.7)	4(12.1)	5(17.2)	5(16.7)	0.25
	30 - 39	9(30.0)	10(33.3)	13(39.4)	15(51.7)	12(40.0)	0.479
	40 - 49	8(26.7)	11(39.3)	12(36.4)	9(31.0)	10(30.0)	0.25
	50 and	4(13.3)	5(17.9)	6(18.2)	8(27.6)	6(20.0)	0.375

	above						
Level of education	Primary	11(36.7)	10(35.7)	20(60.6)	15(51.7)	14(46.7)	1.107
	Secondary	3(10.0)	5(17.9)	7(21.2)	13(44.8)	7(23.3)	2.0
	College/ polytechnic	1(3.3)	2(7.0)	3(9.1)	2(6.9)	2(5.8)	0.25
	University	1(3.3)	1(3.5)	1(3.0)	2(6.8)	1(3.3)	0.25
	None	3(10.0)	5(17.9)	7(21.2)	9(31.0)	6(19.2)	0.55
Marital status	Married	18(60.0)	20(71.4)	25(75.8)	21(72.4)	21(70.0)	0.31
	Single	2(6.6)	4(14.3)	6(18.2)	8(27.6)	5(17.5)	0.85
Religion	Divorced/ Separated	3(10.0)	4(14.3)	2(6.1)	6(20.7)	4(12.5)	0.56
	Catholic	5(16.7)	8(28.6)	13(39.4)	18(62.1)	11(36.7)	2.45
	Protestant	16(33.3)	12(42.9)	17(51.5)	15(50.0)	15(50.0)	0.23
	Muslim	5(16.7)	4(14.3)	13(39.4)	10(34.5)	8(2.5)	1.59
	Traditionali st	2(6.6)	3(10.7)	5(15.2)	6(20.7)	4(12.5)	0.625

Awareness and occurrence of *O. lanceolata* in Kitui County

Most of the respondents interviewed (78%) were aware of the *O. lanceolata* plant material species, against 22% who were not aware. Majority of the respondents 64% reported that it was a taboo to use *O. lanceolata* for firewood against 36% who reported otherwise.

On existence of *O. lanceolata*, it was established that Kitui South Sub - County had slightly more (65.5%) people aware of the existence of *O. lanceolata* plant materials compared to other Sub-counties. Most of the land where *O. lanceolata* was growing was owned by individuals. Kitui South Sub – County had more land ownership with 68.7% compared to other sub – counties ($p < 0.05$). It was also found that Kitui East subcounty had slightly more registered self-help conservation groups with 53.6% compared to other Sub-

counties ($p < 0.05$). More of the respondents (57.1%) in Kitui West than in any other subcounty were trained on *O. lanceolata* propagation techniques ($p < 0.05$).

Awareness on *O. lanceolata* existence was most statistically significant in Kitui Central, Kitui West and Kitui South Sub – Counties ($p < 0.05$). Chi – square analysis showed that there was strong relationship between awareness and harvesting of *O. lanceolata* in the study area. There was a significant Pearson correlation between usage knowledge ($r = 0.744$, $p < 0.01$) with the harvesting trends of *O. lanceolata* from the wild.

Table 3: Community awareness on existence of *O. lanceolata* plant species

Factors	F (%)	F (%)	Chi-square statistic	P-value*
1. Awareness on the existence of <i>O. lanceolata</i> plant species				
Cluster	Exist	Does not Exist		
Kitui West (n=30)	19(63.0)	11(37.0)	6.2111	0.0074*
Kitui East (n=28)	18(64.2)	10(35.8)	5.442	0.1441
Kitui Central (n=33)	21(63.6)	12(36.4)	7.564	0.0001*
Kitui South (n=29)	19(65.5)	10(34.5)	6.321	0.0075*
2. Ownership of land where <i>O. lanceolata</i> grows				
Cluster	Own	Not own		
Kitui West (n=30)	17(56.7)	13(43.3)	8.104	0.0001*
Kitui East (n=28)	16(57.1)	12(42.9)	7.221	0.3411
Kitui Central (n=33)	18(54.5)	15(46.5)	5.497	0.2487
Kitui South (n=29)	20(68.9)	9(31.0)	6.223	0.002*
3. Existence of organized community groups				
Cluster	Exist	Does not Exist		
Kitui West (n=30)	13(43.3)	17(56.7)	9.314	0.0002*

Kitui East (n=28)	15(53.6)	13(56.4)	7.2584	0.0002*
Kitui Central (n=33)	10(30.3)	23(69.7)	5.3321	0.0004*
Kitui South (n=29)	8(27.6)	21(72.4)	6.2475	0.0001*

4. Training on *O. lanceolate* utilization

Cluster	Trained	Not trained	8.365	0.1451
Kitui West (n=30)	16(57.1)	14(42.9)	5.172	0.0047*
Kitui East (n=28)	12(46.7)	16(53.3)	8.214	0.2254
Kitui Central (n=33)	14(42.4)	19(57.6)	6.387	0.0224
Kitui South (n=29)	13(44.8)	16(55.2)	4.215	0.8552

*Significant level at 0.05; frequencies (F), (n) represents respondents

***O. lanceolata* growing habitats and ecosystems**

Majority of the respondents (38.3%) indicated that *O. lanceolata* grew in the forests followed by 26.7% who indicated that it grew on the hill tops. Also 19.2% indicated that it grew on rocky areas while 10.8% indicated that the species grew on farmland. The least was 5% who indicated that it grew along rivers (Figure 2).

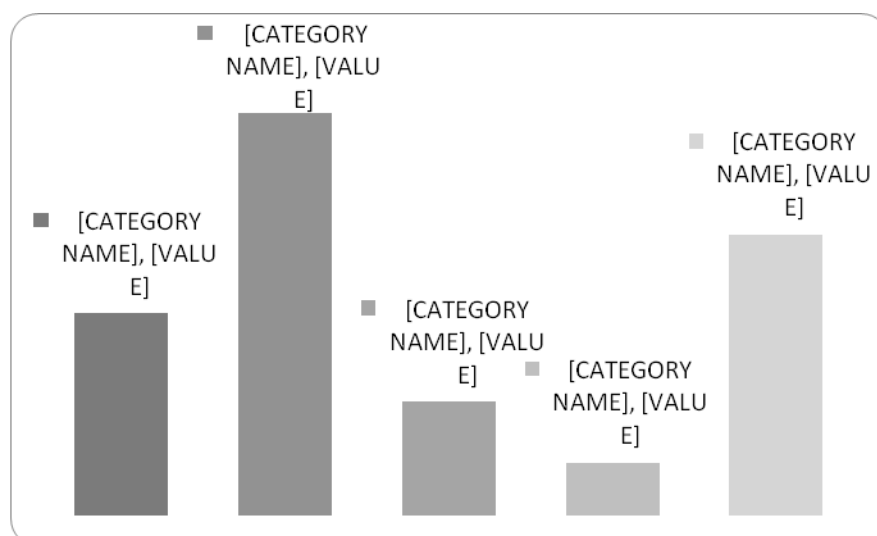


Figure 2: *O. lanceolata* growing habitats and ecosystems

Distribution of *O. lanceolata* in the targeted Sub - Counties

The actual areas where *O. lanceolata* was found growing in Kitui West Sub – County were Kavonge, Kwa Mbelu, Muthale and Musengo. In Kitui East Sub – County the *O. lanceolata* plant species was plenty at Endau Hills while in Kitui Central Sub – County, the plant grows in Wikililye, Chuluni, Kavalula,

Nzambani and Kyanika. In Kitui South Sub – County, the plant grows at Ikanga, Kyatune, Mutha hills and in Mutomo. Figure 3 shows distribution of *O. lanceolata* within the targeted study areas.

There was a significant Pearson correlation between distribution ($r = 0.666$ $p < 0.01$), with the harvesting trends of *O. lanceolata* from the wild.

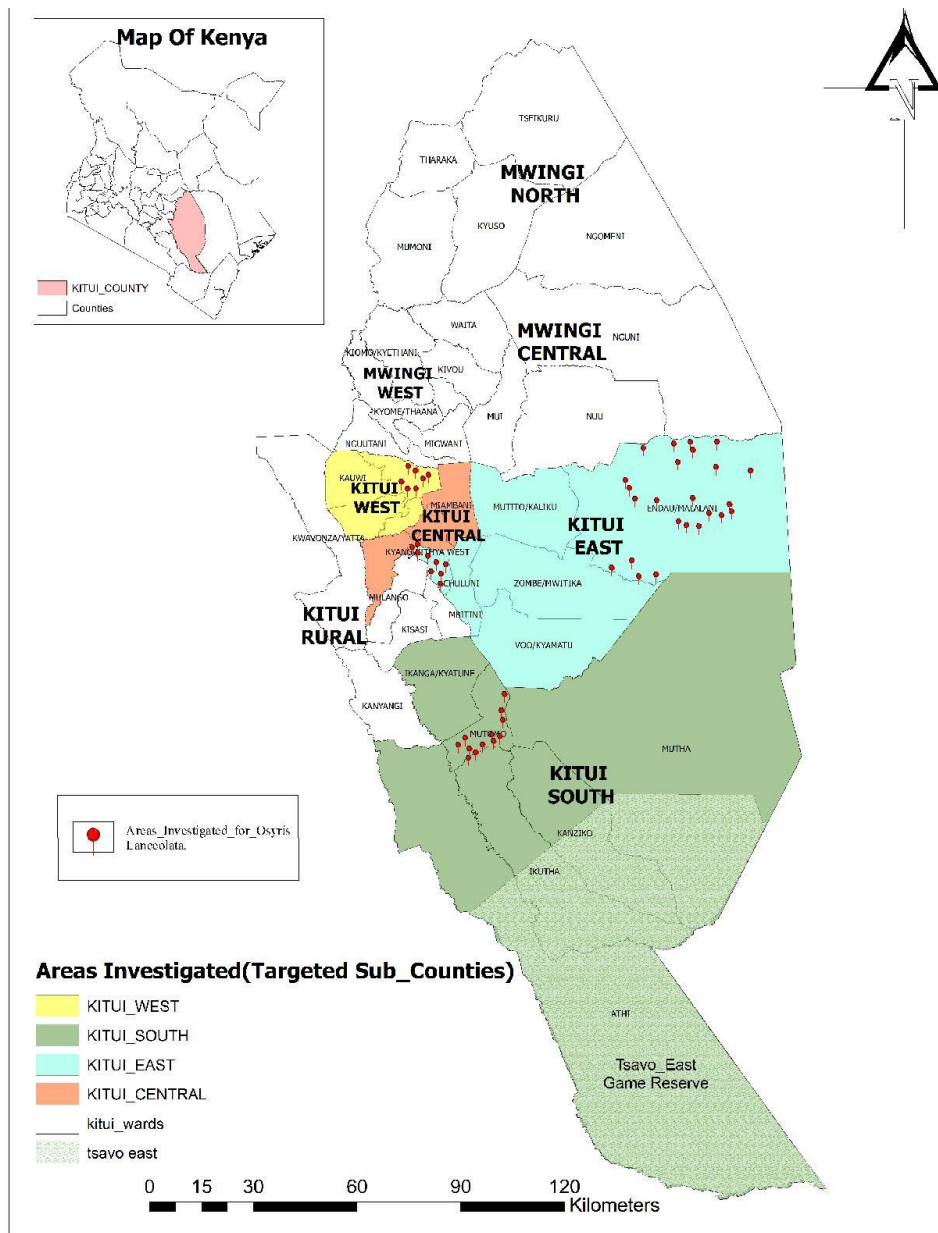


Figure 3: Map showing the distribution of *O. lanceolata* in the targeted study sub – counties in Kitui County

Assessment of the socio - economic benefits of *O. lanceolata* utilization in Kitui County

The logistic regression analysis on the following socio – economic related factors were found significant ($p < 0.05$) in influencing the *O. lanceolata* utilization in the study area: household income sources ($p = 0.036$); land sizes ($p = 0.047$). There was a significant Pearson correlation between household income sources ($r = 0.762$, $p < 0.01$), with the harvesting and utilization trends of *O. lanceolata* from the wild.

The main purpose for harvesting *O. lanceolata* was for income and commercial purposes (44.2%), followed by 39.2% for both commercial and local use, while local use only was by 16.7% of the respondents. However, there was substantial level of illegal harvesting of *O. lanceolata* material from the wild (Plate 1). In Kitui County, incidences of illegal poaching of *O. lanceolata* have been reported for the last three years due to the demand of the plant as raw material for the manufacturing companies. The major beneficiaries of *O. lanceolata* business were the manufacturers (45%) followed by the middlemen (30%). The local harvesters only benefited by 17.5% while the transporters benefited by 5.8% (Figure 4).



Plate 1: Confiscated bags of illegally harvested *O. lanceolata* roots and stems at Kitui Police station

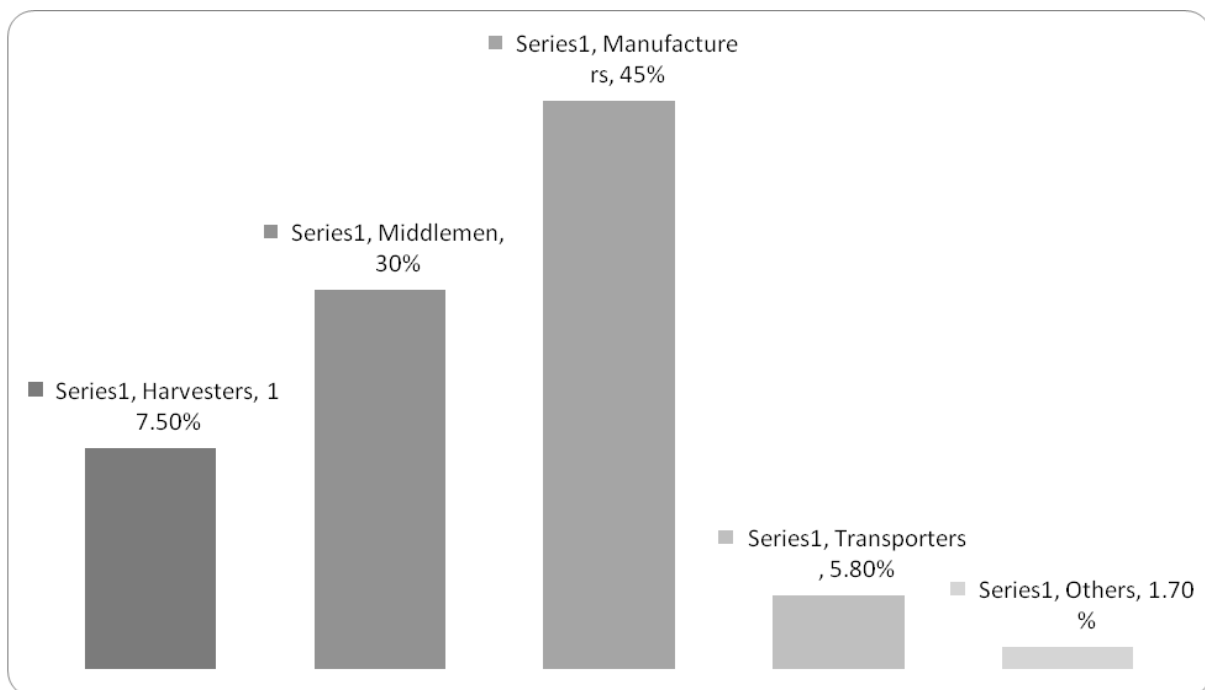


Figure 4: Graph showing *O. lanceolata* plant business beneficiaries

Majority of the respondents (48.3%) reported that they had harvested *O. lanceolata* for less than one year. This was followed by those who had harvested the plant material for a duration ranging between 2 – 4 years (26.7%). Those who had harvested the plant material for a period ranging between 5 – 7% were 14.2% and those who had harvested it for more than 7 years were 10.8%.

Factors that determine selling price for *O. lanceolata* products

Selling price for *O. lanceolata* was mainly determined by the buyers (51.7%), followed by 23.3% of the respondents who indicated that it was determined by the market forces. The respondents who indicated that the selling price of the plant material was determined by the seasons and self were 19.2% and 5.8% respectively.

The study established that one litre of the refined and processed *O. lanceolata* oil price ranges between Kshs. 80,000 to Kshs. 100,000. Majority of the respondents (51.7%) reported that the main customers for *O. lanceolata* were the pharmaceutical companies followed by perfume cosmetics companies at 29.2% (Table 4).

Table 4: Main customers of *O. lanceolata* products

	Frequency	Percent
Pharmaceutical companies	62	51.7
Perfume cosmetics	35	29.2
Food industry	3	2.5
Clothing	2	1.7
Middlemen	18	15.0
Total	120	100.0

Most of the respondents (64.2%) indicated that the plant material was being used for medicinal purposes, followed by the oil production at 25.8%. Construction, wood carving and firewood utilization were least reported at 1.7%, 2.5% and 5.0% respectively (Figure 5).

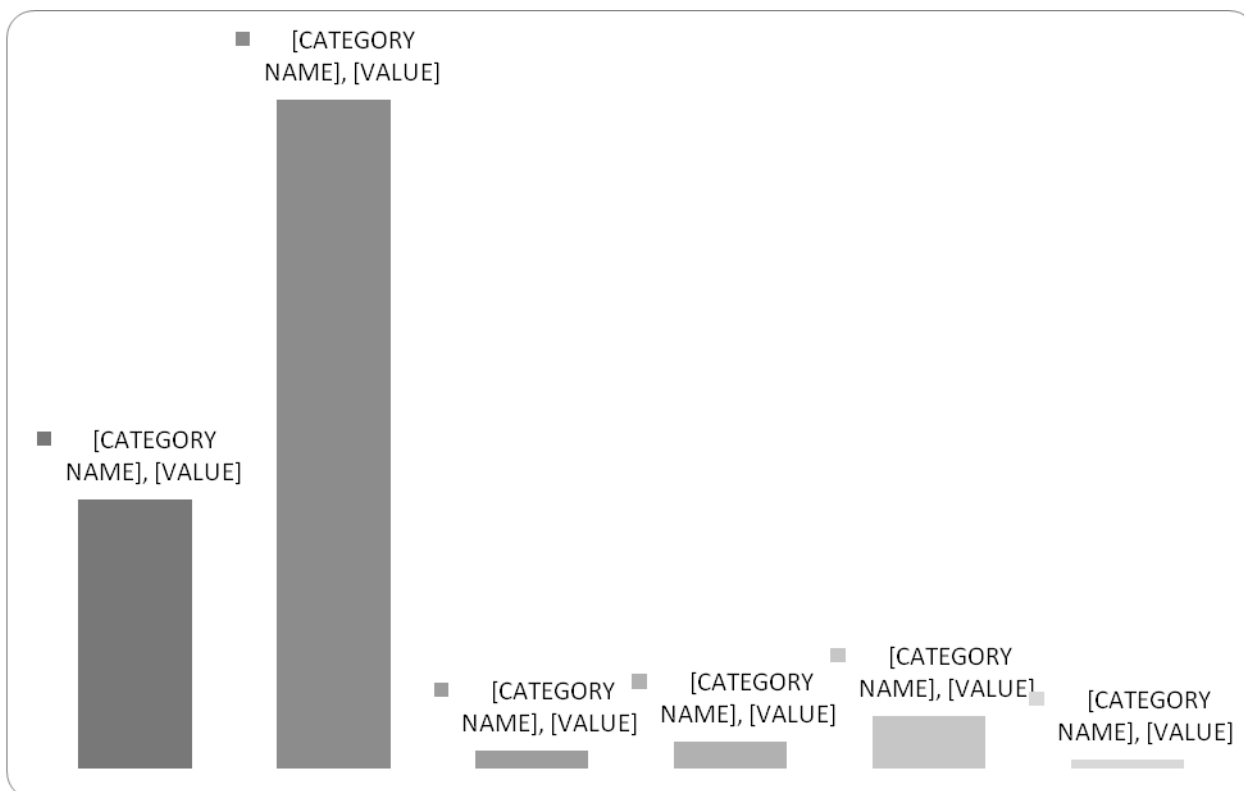


Figure 5: Graph showing *O. lanceolata* major uses

Methods of harvesting *O. lanceolata*

Majority of the respondents (73.3%) reported that the main method for harvesting *O. lanceolata* was by total uprooting. Other methods of harvesting included selective and branch harvesting each at 10.8%, debarking (3.3%) and leaf harvesting (1.7%). Majority of the respondents (42.5%) reported that the roots were the most harvested parts of the plant material, followed by both stem and roots (25%), stem (18.3%), leaves 9.2% and branches 5.0% (Table 5).

Table 5: Methods used in harvesting *O. lanceolata*

Harvesting method	Frequency	Percent
Total uprooting	88	73.3
Selective harvesting	13	10.8
Branch harvesting	13	10.8
Debarking	4	3.3
Leaf harvesting	2	1.7
Total	120	100.0

Majority (42.5%) of the respondents indicated that the part of the *O. lanceolata* plant harvested is the roots. This was followed by those who indicated that it's both stem and roots (25%). Others indicated that it was stem (18.3%), leaves (9.2%) and branches (5%).

The researcher further sought to establish the environmental degradation consequences caused by over – exploitation of sandalwood plant. The responses were presented in table 6.

Major environmental degradation effects

Majority of the respondents (55%) reported that the major environmental degradation consequences caused by over – exploitation of *O. lanceolata* plant materials was increased soil erosion. This was followed by the drop in crop production (29.2%), lack of fodder for livestock (8.3%) and diminishing of water resources (7.5%) (Table 6).

Table 6: Environmental degradation consequences caused by exploitation of *O. lanceolata*

	Frequency	Percent
Drop in crop production	35	29.2
Increased soil erosion	66	55.0
Lack of fodder for livestock	10	8.3
Diminishing of water resources	9	7.5
Total	120	100.0

Discussion

Gender was found to be a significant factor in determining awareness and utilization of *O. lanceolata* utilization in the study area ($p < 0.05$). More males were aware and involved in *O. lanceolata* utilization than females as similarly observed by Helmstadler, (2009), who found that more males than females participated in the harvesting of the *O. lanceolata* plant products. Ochanda, (2011) also showed that most of *O. lanceolata* was poached at night due to high demand for the manufacturers of pharmaceutical and cosmetic products. Most of the respondents had basic education and low income levels. The respondents' main source of income was subsistence farming which included crop farming, livestock husbandry and bee keeping. These findings were also confirmed by Nyerere (2000) who reported that most of the rural communities depend on agricultural farming and animal husbandry as their main sources for livelihoods. The low production levels revealed in the results mean that respondents could have experienced regular crop

failures, frequent livestock deaths due to lack of the pastures and thus they could have resulted to *O. lanceolata* harvesting as an alternative source of livelihood. Similar findings were confirmed by Beentje (1994) who reported that in most cases where communities neighbour natural resources, they tend to exploit those resources and especially when they do not have alternative sources of income. The F-statistics at ($F = 74.619$) revealed statistically significant relationship between *O. lanceolata* harvesting and socio – economic variables including level of education, age, income levels and usage knowledge of the *O. lanceolata*, occupation and land size of the respondents ($p < 0.05$).

Most of the respondents were married and aged between 30 – 39 years, meaning that majority were in the most productive age bracket. This was confirmed by Helmstadler, (2009) who established that most of the natural resources are exploited by the younger generations than the older generations. Due to lack of formal employment most of the respondents could have turned to the harvesting and trading of *O. lanceolata* as a means to raising alternative incomes to sustain their families. The study established that *O. lanceolata* had been known for a long time but apart from the use as firewood and medicine, no other uses were known to the community until the last few decades. This could have been due to the rise in demand of the *O. lanceolata* products in the pharmaceutical and cosmetic industry as reported by Machua *et al.*, (2009). According to them, massive exploitation of *O. lanceolata* started in Tanzania and when *O. lanceolata* populations became too few, the exploitation spilled over to Kenya through Mt. Kilimanjaro area, Chyulu hills and other regions.

As documented by Machua *et al.*, (2009) much of the distribution of *O. lanceolata* was found to occur in dry land forests, stony and rocky areas. This shows that cultivating the tree in the study area could be an appropriate alternative given that most of the ASALs where *O. lanceolata* grows are characterized by either unreliable rainfall or poor unproductive soils as a result of continuous soil erosion. Since most of the people interviewed were aware of the occurrence of *O. lanceolata*, it becomes easy to institute sustainable conservation measures of the plant. In some places like Mutha, a number of respondents seemed not to be very familiar with *O. lanceolata* plant. However, they were aware of the other plant species that are closely associated with the plant, especially the medicinal ones. These findings were confirmed by Mukonyi *et al.*, (2011) who found out that most of the rural populations in Kenya depend on the herbal medicine derived from the world. It was established that most of the *O. lanceolata* plant material grew on communal forests and individual farmlands and this makes it difficult to conserve and protect the plant. This was documented by KFS, (2010) who reported that most of exploitations and unsustainable harvesting of both woody and non-forest forest products occur in the non - gazetted and unprotected areas. In Kitui East sub – county, *O. lanceolata* growing was observed at Endau hills which is a government gazetted forest. Communities indicated that they have not been involved by the government agencies in the protection and conservation of the tree species. In Kitui Central and Kitui West Sub – Counties, the plant species grew on individual

farmlands and this made enforcement difficult to effect. In Kitui South Sub – County, the plant was found to grow in community forests and thus the reason why there has been rampant poaching of the *O. lanceolata* materials and products in the area. There exist challenges on the charges for culprits arrested in possession of illegal *O. lanceolata* materials. There are no clear guidelines in Kenya on how to promote *in – situ* conservation of *O. lanceolata* either through the domestication of the plant species or by any other means. The price of the *O. lanceolata* products has not been established and thus leading to exploitation of the farmers by the middlemen. In Kitui Central, it was reported that the council of elders discouraged the use of the plant material for firewood because it produced an awful smelling smoke. This traditional belief helped to conserve the plant species from unsustainable exploitation from the wild. During this study, it was found that there were no established community groups or guidelines dealing with the conservation and utilization of *O. lanceolata*. However, most of the respondents were aware of the harvesting of the plant species from the wild. Machua *et al.*, (2009) documented that the major mode of harvesting of the plant was uprooting the whole tree hence seriously interfering with its natural regeneration.

A study in the Chyulu Hills in Kenya showed that locals used *O. lanceolata* for commercial and medicinal purposes for the treatment of both animals and people such as snake bites (Ochanda, 2011). Due to illegal harvesting, most of the mature trees have been removed from the wild. Attempts at local nursery propagation have been unsuccessful. According to a report by a government taskforce on the harvesting and trade of *O. lanceolata* in Kenya, it was reported that poverty in the areas where the species occurs was the underlying factor that made the fight against the illegal trade of the plant difficult to win (KFS, 2010). Communities around Chyulu National Park earned Kshs. 4.00 to Kshs. 7.00 for every kilo of *O. lanceolata* harvested, of which the middlemen sold at Kshs. 80.00 per kilo. In the international market, it had been estimated that one litre of the refined and processed *O. lanceolata* oil sells at about Kshs.80, 000.00 – 100,000.00 (Walker, 2006). Mathenge *et al.*, (2005) recorded that wood of *O. lanceolata* is exported to China and India for processing. Processed products were exported to Indonesia, India, South Africa, France, Germany and eastern Asia countries for the cosmetic and pharmaceutical industry. Successful intervention measures therefore required to address poverty and alternative livelihoods (KFS, 2009). Most of the people were involved in the harvesting of the *O. lanceolata* mainly for commercial reasons and respondents felt that it was the manufacturers and middlemen who benefited in the whole value chain. This was so because farmers and local communities who are involved in the harvesting of the plant material did not have skills on where the harvested materials were taken to for more processing. It was observed that commercial harvesting of *O. lanceolata* was fairly a recent activity to the local community and therefore sale prices were mainly determined by the buyers and not by the wild harvesters. The main traded products of *O. lanceolata* included aromatic oils extracted from the heartwood, timber for handicrafts and sawdust for making incense. Heartwood of the trunk, branches and roots contain the essential oils, with highest concentrations in the

roots. The essential oil is used in perfumery, pharmaceutical, religious and medicinal practices. The East African Sandalwood oil has been found to be one of the best essential oil in the world (Machua *et al.*, 2009).

The main method used for *O. lanceolata* harvesting was by use of total root uprooting which caused severe environmental degradation as confirmed in the areas where *O. lanceolata* was mainly found (Ochanda, 2011). In Kenya, the species was protected by Legal Notice No. 3176 under the Forests Act, 2005 which gave protection to the species for a period of five years in order to allow for the development of sustainable harvesting mechanisms (GoK, 2007). Further, the species exploitation is regulated by the Wildlife Management Act Cap. 376, Environment and Management Coordination Act, (amended, 2015) and the Constitution of Kenya, 2010.

During the study, it was found that the main environmental degradation effect associated with unsustainable harvesting of *O. lanceolata* was degradation of water catchment areas. This in turn has caused increased surface run – off, flash flooding, reduced infiltration and increased soil erosion and siltation of the existing water harvesting structures. This was confirmed by Kieti *et al.*, (2016) who reported that once watershed and catchment ecosystems are interfered with, they cease to supply essential ecological goods and services. Furthermore, these factors have threatened the hydrological functioning of forests – water interaction (Chene, 2005). The roots were the most preferred parts with the stems and branches being utilized as source of firewood. Once the roots of a plant are uprooted it means that the soil particles cannot be held together and this exposes the soil to agents of soil erosion FAO, (2015). Other environmental degradation effects reported were drop in crop production and lack of fodder for livestock as also confirmed by (FAO 2015). These occur due to loss of soil fertility whereby once active soil ingredients are washed away, the soil is left bare without sufficient nutrients to support crop production and fodder growth for livestock as similarly reported by Mary (2015).

All the independent variables such as *O. lanceolata* distribution, knowledge on usage, socio – economic benefits and environmental impacts had a positive correlation with the dependent variable, with ($r=0.781$, $p < 0.01$), ($r=0.744$, $p < 0.01$), ($r=0.666$, $p < 0.01$), and ($r= 0.581$, $p < 0.01$) for socio - economic benefits, knowledge, distribution and environmental impacts respectively. According to Murray *et al.*, (1999) there was statistically significant relationship between distribution of *O. lanceolata*, usage knowledge, socio-economic benefits, and environmental impact and the harvesting of *O. lanceolata* from the wild. The regression model on harvesting of *O. lanceolata* = $1.04 + 0.207x_1 + 0.431x_2 + 0.641x_3 - 0.129x_4$ showed that the socio - economic benefit (x_3) had the highest contribution to the model (0.641). This means that a unit change in socio - economic benefit would change the *O. lanceolata* harvesting by a factor of 0.641. This was followed by usage knowledge and distribution with a factor of 0.431 and 0.207 respectively. It was however found that the change in environmental impact had a negative impact on the *O. lanceolata* (-

0.129). These findings were supported by Mary (2015), who established that socio – economic benefits of harvesting *O. lanceolata* contributed highly to its exploitation due to high demand in the market.

Conclusion

In this study, it was established that most of the community members interviewed had received either formal or informal education. Those who had not received any form of education did not know the uses of the *O. lanceolata*. Most people harvested the plant material in order to earn an income. The major beneficiaries in the entire value chain were the manufacturers, middlemen and traders. Majority of the people involved in the harvesting of *O. lanceolata* did not have the necessary skills on how the material should be processed. Pharmaceutical and cosmetic companies were the main buyers of the *O. lanceolata* plant materials. Middlemen and manufacturers determined the selling and buying price of the *O. lanceolata* products. Majority of the people interviewed stated that they had been involved in the business of *O. lanceolata* business for less than a year and this meant that it was a new business to them. The major environmental degradation impact associated with *O. lanceolata* utilization was the increased soil erosion due to the uprooting of the whole plant as the dominant method of harvesting. There is need to put in place sustainable conservation measures and operational regulatory framework to control harvesting of this threatened, yet commercially viable plant species from the wild.

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