SOUTH EASTERN KENYA UNIVERSITY

SCHOOL OF ENVIRONMENT, WATER AND NATURAL RESOURCES

ASSESSING THE UTILIZATION AND SOCIO – ECONOMIC IMPACTS OF *OSYRIS LANCEOLATA (Hochst & Steudel)* AND ASSOCIATED ENVIRONMENTAL DEGRADATION IN KITUI COUNTY

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2020

DECLARATION

I understand that plagiarism is an offence and I therefore declare that this thesis report is my original work and has not been presented to any other Institution for any other award.

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ABBREVIATIONS AND ACRONYMS

AEZ	Agro-Ecological Zones
ASALs	Arid and Semi-Arid Lands
FAO	Food and Agriculture Organization
FG	Focused Group Discussion
GDP	Gross Domestic Product
GIS	Geographical Information System
GOK	Government of Kenya
GPS	Geographical Positioning System
HVMPTS	High Value and Multi – Purpose Trees and Shrubs
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
KEFRI	Kenya Forestry Research Institute
KIF	Kenya's Indigenous Forests
Kshs	Kenya Shillings
NGOs	Non – Governmental Organizations
LULCC	Land – Use and Land – Cover Change
SPSS	Statistical Package for Social Sciences

ABSTRACT

Arid and Semi-arid lands (ASALs) in Kenya are rich in diversity of indigenous plants that have the potential to supply marketable commodities on a sustainable basis such as gums, resins and essential oils, among others. In the recent past there has been rampant unsustainable harvesting of *Osyris lanceolata* in Kenya to produce raw material to support manufacturing industries. The objectives of this study were to map out *O. lanceolata* growing zones in targeted sub – counties, assess the socio – economic benefits of *O. lanceolata* in the selected sub–counties, ascertain the environmental impacts associated with the exploitation of *O. lanceolata* and determine the legal framework associated with *O. lanceolata* utilization. Data was collected using questionnaires and analyzed using Statistical Package for Social Scientists version 20. A total of 120 respondents were interviewed. There were two main uses of *O. lanceolata* wood products; medicinal and perfumery oil production. The main purpose of harvesting *O. lanceolata* was commercial use (44.2%), with little use for domestic purposes (16.7%). The major beneficiaries of *O. lanceolata* business were the manufacturers reported and middlemen. 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. The Chi- square statistic of 6.321 and p-value of 0.0075 were found significant ($p<0.05$). The study established that one litre of the refined and processed *O. lanceolata* oil price ranges between Kshs. 80,000 to Kshs. 100,000. The Chi- square statistic of 6.223 and p-value of 0.002 were found significant ($p<0.05$). On existence of groups, Kitui South had slightly more with 72.4% compared to other sub-counties. The Chi- square statistic of 6.2475 and p-value of 0.0001 were found significant ($p<0.05$). Majority (73.3%) of respondents indicated that the main method for harvesting *O. lanceolata* was total uprooting which ended up causing environmental degradation. The regression model for *O. lanceolata* harvesting = $1.04 + 0.207x_1 + 0.431x_2 + 0.641x_3 – 0.129x_4$. The study established that all the independent variables had a positive correlation with the dependent variable. This means socio - economic benefit (x_3) had the highest contribution to the model (0.641), having the highest correlation of ($r=0.781$, $p<0.01$) followed by the usage knowledge (x_2) with a correlation of ($r=0.744$, $p< 0.01$) and then distribution of *O. lanceolata* (x_3) with a correlation of ($r=0.666$ $p< 0.01$), environmental impact (x_4) had the least correlation of ($r= 0.581$, $p< 0.01$). The study established that, *O. lanceolata* was being exploited. People engage in O. lanceolata harvesting to enhance their livelihoods. The study findings will inform policy making process in Kitui County as the distribution and socio – economic benefits of the *O. lanceolata* in Kitui County have been determined.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Sandalwoods have been exploited for over a long period and the plant material populations are declining very fast due to uncontrolled harvesting in order to meet demands for industries which process cosmetics and fragrance products and especially amongst Indo – pacific Islands (Orwa *et al*., 2009). Worldwide *O. lanceolata* plant materials stems and roots have high value oils derivatives. The most priced sandalwood is *Santallum alba*, the Indian Sandalwood (Kamondo *et al*., 2014). The sandalwood oil blends well with many fragrance materials, making it a common blender fixative used in many perfumes. Many religions including Hindus, Buddhists, Chinese and Muslims use sandalwood as incense during prayers and ceremonies because of its sweet fragrance (Ochanda, 2011).

The African sandalwood has different genus and species. *Spirostachys africana* which is also known as *Tamboties / Tamboote* or the *Coco bola* of Africa is mostly found in Mozambique (Madeiras, 2008). In Tanzania *O. lanceolata* also commonly referred to as Carratt or Carrat or *Kitandae* (Chagga) or *Kipaat* (Iraqw) is commonly found mainly distributed around the Sagassa area. Other countries where *O. lanceolata* is found include Zimbabwe and South Africa. Traders discovered the East African Sandalwood and set up processing industries and trading basis in the region. The industries provided market for the O. lanceolata products from Kenya, Tanzania and Uganda. By the year 2004, the exploitation of the species in East African countries was a matter of concern. A part from the vast Sandalwood quantities that were being obtained from the natural habitats illegal harvesters uprooted the entire plant materials which further threatened future existence of the Sandalwoods in the region (Kamondo *et al*., 2014). Sandalwood plant species occurring in Eastern Africa have been protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix 11. *Osyris lanceolata* is a small tree with Kenya as one of its major distribution range and especially in Kitui County (Kamondo *et al*., 2014). The plant is locally known as, *munyungamai, ndonga or kithawa* (Kikamba), *msandali / mti wa marashi* (Swahili), *muthithi* (Kikuyu), *mberegesa* (Chagga), *Olseyeayyesi* (Maasai)". The plant is known to grow in hilly and semi - humid areas in Kitui County (Kamondo *et al*., 2014).

The *O. lanceolata* belongs to the family Santalaceae and it hemi – parasitic shrub, small tree growing to a height of up to six meters. The species is dioecious, meaning male seeds are found in different tree from that bears female seeds. East African Sandalwood is a hemi-parasite with its roots attaching to the roots of host plants from which they absorb nutrients (Mathenge *et al*., 2005). *O. lanceolata* is associated with other plant species such as *Harrisonia abbysinica, Euclea divinivorum, Lantana camara, Cajan cajanis, Rhus natalensis, Rhus vulgaris, Maytenus acuminate, Croton megalorcapus, Acacia kirkii, Grewia similis and Dandonea viscosa* amongst others (Kamondo *et al*., 2014).

O. lanceolata is one of the sandalwoods in the world known for producing good smelling stems and roots oil. Oil is highly used in various cosmetics and fragrance industries and has gained popularity also in medicine industries (Dwivedi & Ahang, 1999).

The plant material has been known to have many uses which range from social, economic, religious and recreational uses. The plant use depends on the locality where the tree occurs. The demand of *O. lanceolata* is higher than the supply globally (Krotz *et al*., 1994).

It has been established that, the concentration of the essential oil is in the roots and stems of the *O. lanceolata*. In Kenya there is massive illegal harvesting of *O. lanceolata* through the uprooting of the whole trees and shrubs. This mode exploitation not only threatens the survival of the species in the wild but it also threatens the sustainability of the trade in the *O. lanceolata* products. This in turn leads into severe environmental degradation (Mukonyi *et al.*, 2011).

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.

1.2 Statement of research problem

There is general lack of the information on *O. lanceolata* distribution and utilization in Kitui County. This is coupled by a lack of any existing national and county policies and guidelines on the conservation and sustainable utilization of *O. lanceolata* (Kamondo *et al*., 2014). *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 in the trunk (Mwang'ingo *et al*., 2003).

It has been established the while the *O. lanceolata* the resource base is reducing but the demand for *O. lanceolata* oil and products have been rising (Mathenge *et al.*, 2005).

1.3 Objectives of the Study

1.3.1 Overall Objective

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

1.3.2 Specific objectives are;

i. To map out *O. lanceolata* growing zones in four targeted sub counties of Kitui County.
ii. To assess the socio - economic benefits of *O. lanceolata* in Kitui County.
iii. To ascertain the environmental impacts associated with the exploitation of the *O. lanceolata* plant species in Kitui County.
iv. To determine the legal framework associated with *O. lanceolata* utilization in Kitui County.

1.4 Research Questions

i. What is the ecological distribution of *O. lanceolata* in Kitui County?
ii. What are the existing socio – economic benefits of *O. lanceolata* utilization in Kitui County?
iii. How does the environmental impacts affect the utilization of *O. lanceolata* in Kitui County?
iv. How is the existing legal framework govern sustainable utilization of *O. lanceolata* in the country?

1.5 Significance of the study

The study findings informs policy making in Kitui County as the study sought to determine the distribution of the *O. lanceolata* and established socio-economic benefits associated with its utilization. The study has filled an academic gap and added knowledge on conservation and management of *O. lanceolata* plant in Kitui County. The study brought out insights on the environmental effects of exploiting the *O. lanceolata* in the County.

Both the National and the County Governments will benefit in understanding how *O. lanceolata* is currently being managed and how better the species can be managed for sustainable utilization. The study served as a baseline for more detailed studies to come up with comprehensive propagation and multiplication methods in order to meet the ever increasing demand of *O. lanceolata* products. The study generated sufficient information which will be useful in the development of the policies and strategic management plans for sustainable utilization of *O. lanceolata* both in the county and also in the country.

1.6 Assumptions of the study

The basic assumption of the study was that the County Government of Kitui would be able to provide all the logistical support required in this study. It was assumed there would be cooperation amongst various groups and individual respondents that were interviewed. These included the general community members, farmers or group representatives and key informants/stakeholders respondents. It was assumed that the respondents understood questions well and answered them correctly. Information obtained from all the respondents was factual and the sample size was representative. The researcher accessed all the sampled respondents in this study.

1.7 Conceptual Framework

The conceptual framework was derived and based on the fact that *O. lanceolata* utilization was dependent upon the distribution of *O. lanceolata*, knowledge on usage, socio – economic benefits and environmental impacts of harvesting *O. lanceolata*. It was assumed the *O. lanceolata* distribution depended was affected by the places where the plant grew, land sizes of the households neighboring the plant material and the duration the plant had been growing. Knowledge on usage of the plant material was affected by the training skills of the users, usage or purpose of the harvested plant material, land ownership and part of the plant material harvested. Socio – economic benefits factors selling affected by the selling strategies of the harvested plant material, amount of money earned and the use of money earned by the participating households. Environmental impacts associated with the harvesting of *O. lanceolata* were harvesting methods, disposal of wastes and effects on the environment. The dependent variable was the utilization of *O. lanceolata* and factors were effect on financial

status, effect on the county economy and documentation. The moderating variables for this study were government and traditional believes.

The figure 1.1 below summarizes the study conceptual framework.

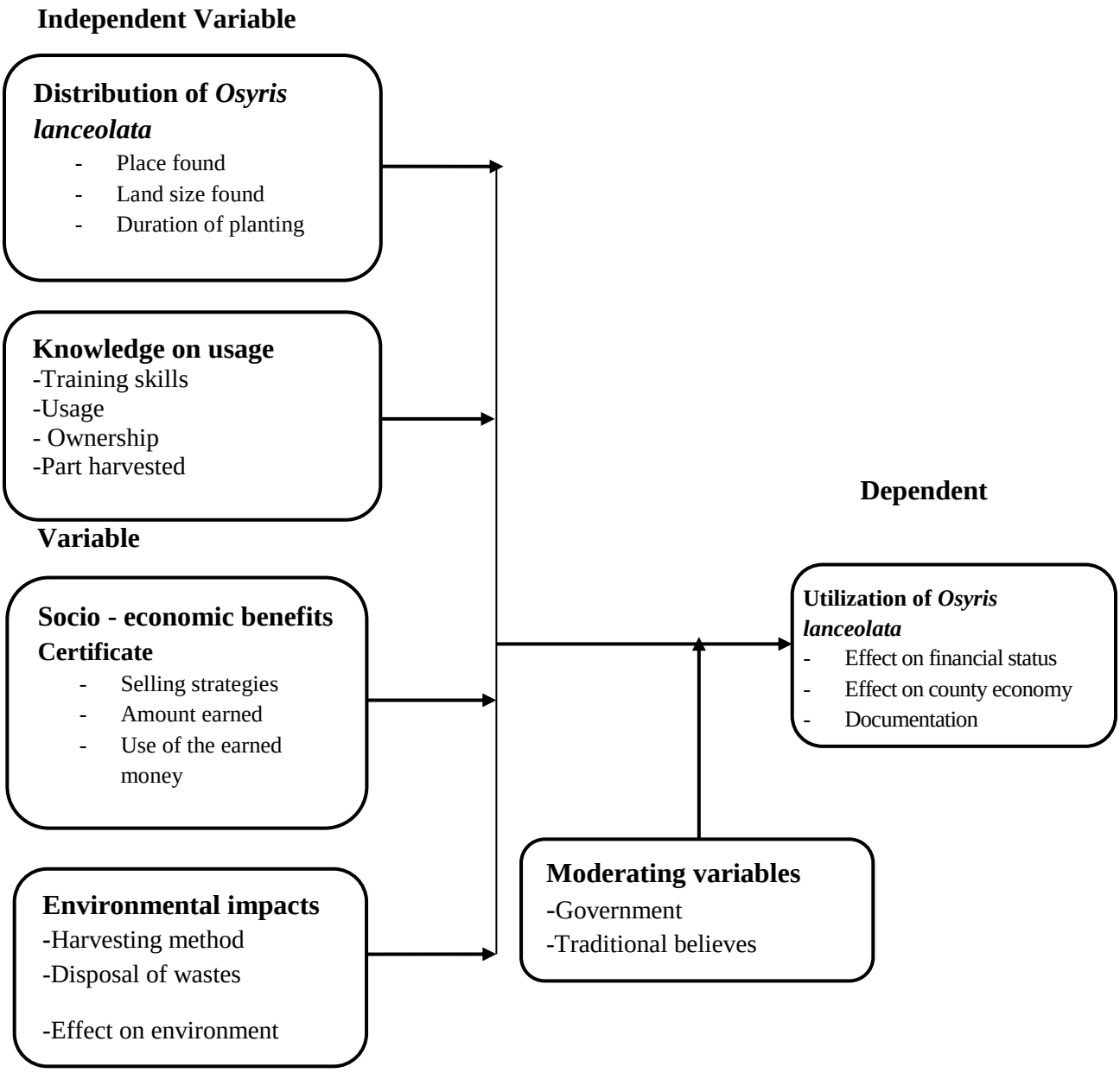

Figure 1.1: Conceptual framework on factors affecting utilization of *O. lanceolata*

The study model was fitted using the formulae as depicted below;

Harvesting of *O. lanceolata* = $X_1 + X_2 + X_3 + X_4$ where;

X_1 = *O. lanceolata* distribution

X_2 = Knowledge on usage of *O. lanceolata*

X_3 = Socio – economic benefits associated with *O. lanceolata* harvesting

X_4 = environmental impacts associated with *O. lanceolata* harvesting

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Land Use and Land Cover Change concept in forestry management

Land – Use and Land – Cover Change (LULCC) is a general term for direct and indirect consequences of human modification of the Earth's terrestrial surface to secure essential goods and services. LULCC drives changes such as climate change, biodiversity loss and pollution of water, soils and airin ecosystems and environmental processes at local, regional and global scales (Mertz, 2005). Land cover refers to the physical and biological cover over the surface of land, including vegetation, water, bare soil, and or artificial structures (Mertz *et al*., 2007). The change in land cover can take place in two ways: inside a class (for instance change of closed woodland to open woodland) or between classes from bush land to grassland (Masalin, 2005). Land use is defined by natural scientists in terms of syndromes of human activities such as agriculture, forestry and building construction that alter surface processes. Social scientists and land managers define land use more broadly to include the social and economic purposes and contexts for and within which lands are managed (or left unmanaged) (Mertz *et al*., 2007). While land cover may be observed in the field or by remote sensing observations of land use and its changes generally require the integration of natural and social scientific methods to determine which human activities are occurring in different parts of the landscape, even when land cover appears to be the same (FAO, 2015). As a result, scientific investigation of the causes and consequences of LULCC requires an interdisciplinary approach integrating both natural and social scientific methods (Mertz *et al*., 2007).

2.2 Forests and deforestation

Currently, forest degradation and deforestation are major contributions to the total global greenhouse gas emissions (UNEP, 2012). Deforestation and forest degradation are significant causes of global warming, accounting for a minimum of 20% of global greenhouse gas emissions (FAO, 2015). This makes the loss and depletion of forests and habitats a major issue for climate change mitigation and adaptation (Obersteiner *et al*., 2010).

Deforestation is thus a major contributor to climate change and with the increased natural disasters experienced all over the world. Some countries such as Rwanda, Chile, China and Vietnam have reversed the trend of national deforestation through the domestication and conservation of the High Value and Multipurpose Trees and Shrubs (Barrett, 2013).

2.3 Socio – economic uses of *O. lanceolata*

The shrub yields a commercially important tricyclicα-santalolβ-Santalolaromatic oil (Beentje, 1994). *O. lanceolata* is exploited for its essential oils used in perfumery. This is found in heartwood of the trunk, main branches and roots. This oil blends well with many fragrance materials that it has become a common blender-fixative used in numerous perfumes (Kamondo *et al*., 2014). Traditionally, *O. lanceolata* processed products have been used for a long time in religious functions and other ceremonies (Wass, 1995). The *O. lanceolata* plant has been used to treat many ailments ranging from baby rashes to malaria (Ochanda, 2011).

There is such an increased demand for Indian sandalwood that the price has been rising, making it the most expensive essential oil available on the market. Globally the demand for *O. lanceolata* products is ever increasing and as a result there has been massive exploitation and illegal harvesting of *O. lanceolata* plant material to meet the demand. It is usually believed old trees produce high quality oil. The age of the plant species should be more than 50 years (Njenga *et al.,* 1999).

Two primary molecules which compose the essential oil in the *O. lanceolata* are alpha- and beta-santalol. The molecules when processed with other ingredients produce the strong fragrance associated with sandalwood products (Foden & Potter, 2005).

Sandalwood oil contains more than 90% *sesquiterpenic alcohols* of which 50-60% is the *tricyclicα-santalolβ-Santalol* comprising 20-25% (Dwivedi *et al*., 2003). *O. lanceolata* oil is used widely as a base note in modern perfumery and cosmetic production. The oil is highly valued for its deep, woody aroma. The oil is generally steam-distilled from the heartwood and roots of *Santalum album*, which can retain their distinctive fragrance for decades (Dwivedi *et al*., 2003). Due to its increasing rarity, sandalwood is among the most expensive perfume ingredients and is most commonly found in designer fragrances (Benencia & Courreges, 1999). Santalol is the main determinant of sandalwood oil quality. As a result, many species of plants within the genus Santalum are traded as "sandalwood". *O. lanceolata* blends well

with most oils worldwide (Mwang'ingo *et al.*, 2003). The list includes Clove Bud, Lavender, Geranium, Patchouli, Jasmine, Benzoin, Bergamot, Clary Sage, Coriander, Cypress, Fennel, Frankincense, Galbanum, Myrrh, Palmarosa, Pepper Black and Peppermint (Heuberger *et al.*, 2006). *O. lanceolata* oil is obtained using steam distillation of powdered wood soaked in water for about 48 hours. Distillation is carried out at a steam pressure of 1.4-2.8 kg/cm^2 for 48-75 hours. The oil content is about 10% in roots and 1.5-2% in chips which have a mixture of heartwood and sapwood (Daniela *et al.,* 2014).The fragrance of sandalwood has relaxing properties and also reduces stress and promotes restful sleep. It is reputed to be an aphrodisiac. Sandalwood oil provides perfumes with a striking woody base note. Sandalwood smells not unlike other wood scents, except it has a bright and fresh edge with few natural analogues. When used in smaller proportions in a perfume, it is an excellent fixative to enhance the other fragrances. The oil from sandalwood is widely used in the cosmetic industry and is expensive (Foden & Potter, 2005). If well processed and packaged *O. lanceolata* products produced from Kitui County could also be exported to other countries and this will not only impact on the economy of Kitui County but also nationally (KFS, 2009). Coupled with poor germination rates, slow growth rates and attack by diseases and pests, exploitation of the plant is having a detrimental impact on the population of the species (Craven & Loot, 2002).

According to Mwang'ingo (2012), the use of *O. lanceolata* began in late 1950s in Tanzania. Increased use of this species began in the early 1990s as a result of decrease in the global *O. lanceolata* supply leading which led to the decrease in the resource and disappearance of the species in some areas. *O. lanceolata* sourced from Africa will remain largely a global resource for the next 10 – 20 years. According to Malimbwi *et al.*, (2006) illegal harvesting began in Tanzania in 2004 and spread to other of other parts of Africa. Kenya is now leading in supply of the *O. lanceolata* raw materials in East Africa. *O. lanceolata* was listed as a species of concern in the list of South Africa plants in 2005 (Foden & Potter, 2005) and as low risk concern in the Southern African Plant Red Data List of Namibia in 2002 (IUCN, 2013).

In Kenya, *O. lanceolata* species has a wide but scattered distribution and population occurrence. During the field surveys of this study very few tree seedlings and saplings were

observed meaning the plant species may be extinct in the near future. Studies by Kenya Forestry Research Institution have revealed poor regeneration potential (Ochanda, 2011). Populations have been declining since 2000 as a result of the uncontrolled and illegal harvesting due to high demand of the plant material. Increased extraction of *O. lanceolata* plant materials in Africa is generally believed to be directly linked to high demand for the production of perfumes and cosmetics. In the Republic of Tanzania, declining populations have been recorded in various parts of the country including Arusha, Manyara and Kilimanjaro and the Eastern Arc Mountains (Kamondo *et al.,* 2014).

2.4 Existing efforts on conservation and management of *O. lanceolata*

There are reported cases of unsustainable exploitation of the *O. lanceolata* from the East African countries. Highly affected counties in Kenya are Kitui, Taita Taveta, Samburu and Makueni (KFS, 2009).

There are joint efforts by the East African countries to initiate programs for carrying out species conservation status assessments that would lead to the reduction of exploitation of *O. lanceolata* plant materials. Both countries have initiated baseline surveys as a basis for species monitoring (Orwa *et al*., 2009). Scientific information generated in Kenya has established that most of the remaining plant species of *O. lanceolata* are found in the gazetted and protected areas and most of the illegal harvesting has been happening in the individual and community forests (Mwangi'ngo, 2012). According to Kenya Forest Service, (2010) it has been established it is very difficult to enforce the presidential ban on sandalwood exploitation in Kenya. Kenyan Wildlife Service (KWS) was given additional mandate to ensure the sandalwood is well protected and conserved within the protected areas (Karanja, 2012). Kenya Forestry Research Institute (KEFRI) has set up demonstration trials at Muthale and Chuluni for the monitoring of the growing patterns of the *O. lanceolata* species. The demonstration plots act as centres for trainings and community awareness (Kamondo *et al*, 2014).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 General characteristics of Kitui County

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 km^2 including 6,369 km^2 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 $0^0$10' and 3^0south and longitudes $37^0$and $39^0$0'East. (KCIDP 2013 - 2017).

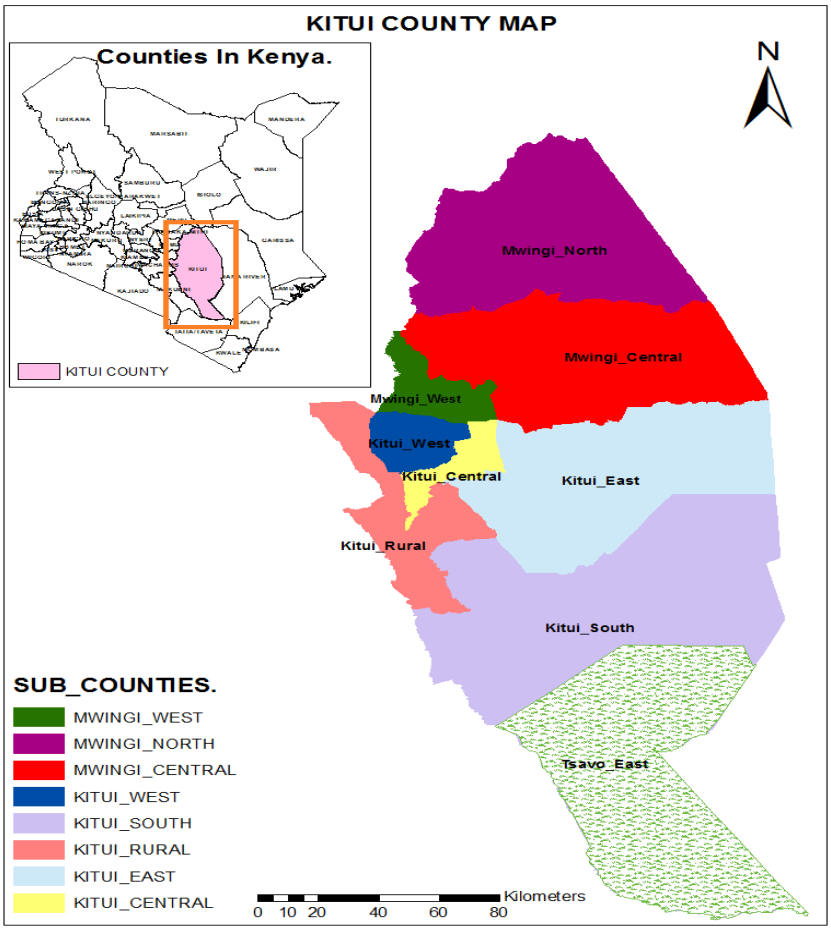

Figure 3.1: Position of Kitui County in Kenya (County Government of Kitui, 2017)

3.2 Physiographic and natural conditions of Kitui County

Kitui County rainfall distribution is erratic and unreliable. The highlands namely; mainly hills of Mumoni, Migwani, Mutonguni, Museve, Mutitu, Endau and Mutha are more productive compared with lowlands of Yatta plateau, Kitui South, Kitui East, Nguni and Tseikuru. These ranges and hilltops due to their altitudes relatively receive more rainfall and thus are key biodiversity areas in the county (Malonza *et al*., 2006).

Kitui County is classified into various zones which range from very small pockets and semi – arid farming zones including UM3-4 the transitional marginal coffee farming arears around Migwani and Kitui Central. The UM4 zone supports commercial cash crops. LM3 is mainly cotton zone and is very small and has many steep slopes mainly for forest reserves. Lower and other marginalized zones mainly support livestock farming and the main agricultural crops and basically drought resistant crops such as cassava, green grams, millet and sorghum among others and here no rain-fed agriculture is suitable (Jaetzold & Schmidt, 1983).

3.3 Climate of Kitui County

The climate of Kitui County is hot and dry for most of the year and is characterized as an ASAL with very unreliable rainfall. The high rate of evaporation, with unreliable rains, limit intensive and meaningful land use and other related development activities (KIDP 2013 - 2017).

The County experiences two rainy seasons with long rains coming from April to May and short rains in November to December. The latter is, however more reliable. The amount of rainfall follows the topographical nature of the landscape. Mumoni Hills in far North, Central Kitui and Mutito Hills in eastern part of the county receive 500-1,050 mm per year, while the eastern and southern lowlands receive less than 500 mm per year (Malonza *et al*., 2006). The minimum mean annual temperature vary from 14 to 18°C in the western parts to 22°C in the eastern parts while the maximum mean annual temperatures range from 26°C to 30°C in the western parts and 30°C to 34°C in the eastern. Annual rainfall at Kitui town, UM4 at 1,158 m altitude 1,014 mm is on average for 29 years of recording and Ikutha market, LM5 at 732 altitude has total 648 mm after 25 years of recording (Jaetzold & Schmidt, 1983).

3.4 Ecological zones of Kitui County

Moisture availability zones: The study area has four main climatic zones that is II-3, IV-2, V-1 and V, though overall, they range from II-2 to V-2. Kitui South Sub-County is mainly represented by agro-climatic zone V-1 except for isolated areas, mainly hills around Endau and Mutha, where zone IV-2 have been identified. The majority of the areas of Kitui West and Kitui Central Sub–Counties lie in agro-climatic zone V-2 and zone III in the upland areas such as Matinyani, Musengo and Mutonguni Wards. Three major agro-climatic zones are represented in Chuluni ward: zone V-1 is in Thua unit, parts of Mbitini and Kisasi wards. Zone V-2 can be identified in parts of Kisasi and Mbitini while Nzambani wards is mainly a zone IV-2 area. Kitui Central Sub-County has diverse climatic zones ranging from zone IV-2 while other parts are in zone V-1. Zone V-2 is mainly found in Itoleka, Katulani and Maliku locations. The study area falls between moisture availability zones II and VI with the following distribution (r is average annual rainfall in mm and E_0 is average potential evaporation, so r/E_0 gives the degree of aridity as %) (Jaetzold & Schmidt, 1983).

3.5 Environment and socio – economic status of the Kitui County

The Kitui county economy primarily depends on natural resources as majority of the population live in the rural areas and derive their livelihood mainly from these resources. These economic activities include farming, jua kali and handcraft industry, energy, mining and the utilization of High Value and Multi – Purpose Trees and Shrubs (HVMTS) among others (Wagombe, 1998). The environment and natural resources have in the recent past been under threat due to increased dependence on natural resources to meet human beings basic needs (Mathenge *et al* 2005). The population growth rate of Kitui County is at 2.1% which is slightly lower than the national growth rate of 2.6% (KNBS, 2009). Rapid population growth is exacerbating the existing problems of imbalance between human numbers and the available arable land with deforestation, poor land use systems and inappropriate farming methods leading to food crises and land degradation (FAO, 2015).

3.6 Human population and demographic features

In accordance to the Kenya National Bureau of Statistics report for 2009 Kitui County human population stood at 1,012,709 according to the population and household census report (KNBS, 2009). The report further showed that 531,427 were females while 481,282 were males. The population growth rate of Kitui county stands at 2.1% which is slightly lower than the national rate of 2.6%. Kitui Town is the largest town in Kitui County with a population of 155,896 which is approximately 15.4% of the County population (KNBS, 2009).

3.7 Specific Study Sites

The study was carried out in four selected sites namely Endau, Mutomo, Mutonguni and Mulango (Table 3.1). These are sites where *O. lanceolata* is known to grow in Kitui County.

Table 3.1: Details of location of the survey areas in the targeted sub - counties

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

3.8.0 Survey design

Information was gathered using multiple methods including field surveys, focused group interviews, key informant interviews, and GPS in combination of Geographic Information Systems (GIS) techniques (Michael, 2014). Triangulation, which is a form of cross-checking and the use of both qualitative and quantitative methods in studying the same phenomenon for the purpose of increasing study credibility were also used (Murray & Larry, 1999). Triangulation of data information sources is highly desirable especially when examining complex system interactions such as socio – economic benefits phenomenon and associated environmental degradation aspects. According to Mugenda, (2011), survey research design was useful not only in securing evidence concerning an existing situation or current conditions but also identifies standards or norms with which to compare present conditions in order to plan the next step. Endau, Mutha, Chuluni and Mutonguni Hills were purposively selected for investigation based on having high *O. lanceolata* populations and distribution, density and varied physical characteristics. The design was also useful in describing the characteristics of a large population, making use of large samples, thus made the results statistically significant even when analyzed using multiple variables. Many questions could thus be raised on a given topic giving considerable flexibility to the analysis. The design allowed the use of various methods of data collection like questionnaire and interview methods and it also made use of standardized questions where reliability of the items were determined (Yogesh, 2006).

3.8.1 Sampling procedures and sample size

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 according to Ranjit, (2011). This method was used to select four sub-counties and from each sub – county one location and one sub – location were selected.

Based on the total population of people living in the four sub-counties totaling 573,000, the total number of households was determined by dividing by 5 which was the assumed average household size according to the Kenya National Bureau of Statistics, KNBS 2009, giving

total households as 114,600. The Households that were interviewed (Sample size) were determined with the formula;

$$n = \frac{N}{1 + N(\propto)^2}$$

Where 'n' is the sample size

'N' is the total number of households.

'$\propto$' is the margin of error estimated at 5% (0.05)

$$n = \frac{114{,}600}{1 + 114{,}600(0.05)^2} = 399 \cong 400$$

Since there are four sub-counties, the sample size per sub-county was arrived at by dividing 400 by 4 giving 100 households per sub-county. Because of time and cost implications, during the study 30% of the selected households per sub-county were interviewed making a sample of 30 households per sub-county (Mugenda, O. & Mugenda, A., 2003). Since there were four sub counties, then the total sample interviewed was 30 x 4 = 120 households. These households were selected using systematic sampling with a rule where one household was selected after every 10 homes.

Investigations on the *O. lanceolata* harvesting variables was done by employing regression analysis. Logistic regression allows one to predict a discrete outcome from a set of variables that may be continuous, discrete and dichotomous or a mix of any of these. Various utilization studies have used logistic regression models for identifying the impacts of independent variables on dependent variables.

3.8.2 Data collection

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 the county (Mugenda, 2011). Secondary data was also collected through review of documents from the existing programmes and from the relevant government departments. The definition of "household" adopted for the purpose of this study was "all the persons

eating and cooking together from the same pot''. That meant that it excluded the general extended family members residing in the same homestead (Orodho, 2008). However older members with sufficient knowledge on useful trees and shrubs in the area were preferred in the interviews.

3.8.3 Data collection procedure

Two enumerators were engaged to administer questionnaires in each of the four targeted sub-counties. The interviewees targeted were farmers, business people, administrators and retired government officers and other key opinion leaders. In total 120 questionnaires were administered. The information was given by either the head of the household or any other person responsible in the household. In addition, a total of 20 key informants were interviewed.

Focused Group Discussions (FGDs) were held in all the four selected sub-counties, with the first one held on the first day of the study in Kitui West Sub–County in Mutonguni location. FGDs in the other three sub-counties were conducted in Mutha location in Kitui South Sub - County, Mulango location in Kitui Central Sub-County and Endau location in Kitui East Sub-County.

3.8.4 Statistical data analysis

Statistical Package for Social Sciences (SPSS) version 20.0 was used to analyze data. The raw data was organized into themes and patterns based on the study objectives and questions (Orodho, 2008). Geographical Position Systems (GPS) was used to identify distribution localities of *O. lanceolata* in the study area. The Geographical Information System (GIS) was used to analyze GPS data collected during the field exercise. The final products were visual maps produced showing areas where the study was carried out and also *O. lanceolata* distribution. Descriptive analysis involved graphs, tables, percentages and means while inferential statistics used were regression model summary, correlations, Chi – square and ANOVA.

CHAPTER FOUR

4.0 RESULTS

4.1.0 Demographic information of the respondents

The demographic information for this study included; gender, level of education, marital status and age of the respondents (Table 4.1). Analyses showed that majority (55.4%) of the respondents were males while minority (44.6%) were females. The respondent was the household head or any other responsible person found at home during the surveying.

Majority (40.0%) of the respondents were aged between 30 – 39 years of age. Respondents aged between 40 - 49 years were 30%. This was followed by those above 50 years (20%). Those aged below 30 years were least with 16.7%.

Primary level of education had the majority (46.7%) of the respondents. Those who had secondary level of education were 23.3% and those who had no any for form of education were 19.2%. Those who had up to college level of education were 5.8% and the least were those who had attained university level of education (3.3%).

It was also established that majority (70%) of the respondents were married. However, 17.5% were single while 12.5% were divorced. On religion, it was observed that majority (48.3%) of the respondents were protestants followed by catholic with 36.7%. There were however 12.5% traditionalists and 2.5% Muslims.

The logistic regression results on socio – economic factors were found significant (at $p < 0.05$) 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* ($p = 0.038$). The following other factors were found insignificant (at $p > 0.05$) in influencing the *O. lanceolata* utilization: age ($p = 0.760$); marital status ($p = 0.0821$); religion ($p = 0.0673$).

Table 4.1: Demographic information of the respondents in the four targeted sub – counties in Kitui County

Research Parameters							
N=120		**Kitui West**	**Kitui East**	**Kitui Central**	**Kitui South**	**Mean**	**Std. deviation**
		n=30	**n= 28**	**n=33**	**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 above	4(13.3)	5(17.9)	6(18.2)	8(27.6)	6(20.0)	0.375
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
	Traditionalist	2(6.6)	3(10.7)	5(15.2)	6(20.7)	4(12.5)	0.625

Figures in parenthesis are percentages of the respondents

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

The first objective for this study was to map out *O. lanceolata* in the targeted four sub counties in Kitui County. To achieve this objective the respondents were first asked whether

they were aware of *O. lanceolata* plant material and also whether there were any groups dealing with the conservation and management of the species (Table 4.2).

Most of the respondents interviewed were aware at 78% of the *O. lanceolata* plant material availability and uses while those who were not aware were only 22%. Most of the respondents (64%) communicated 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. On ownership, most of the land where *O. lanceolata* was growing was owned either by clans or individuals. On existence of organized community groups, Kitui East had slightly more registered groups with 53.6% compared to other Sub-counties ($p < 0.05$). On *O. lanceolata* propagation training techniques, it was established that, Kitui West had more trained respondents 57.1%.

Awareness on *O. lanceolata* existence was most statistically significant in Kitui Central and Kitui West Sub – Counties ($p < 0.05$). There was strong relationship between awareness and harvesting of *O. lanceolata* in the study area. On ownership of land where O. lanceolata grows only Kitui West and Kitui South Sub – Counties were significant ($p < 0.05$). On existence of organized community groups all the targeted four sub – counties were significant ($p < 0.05$), while only Kitui West Sub – County was significant ($p < 0.05$) on training on *O. lanceolata* utilization.

Table 4.2: Community awareness on existence of *O. lanceolata* plant species in the four targeted sub – counties in Kitui County

Factors	F (%)	F (%)	Chi-square statistic	$P^{\text{-value}*}$
1. Awareness on the existence of *O. lanceolata* 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 *O. lanceolata* 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. lanceolata* 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. Figures in parenthesis are percentages of the respondents

4.2.1 *O. lanceolata* growing habitats and ecosystems

Majority of the respondents 38.3% indicated that *O. lanceolata* grew in the forests. Respondents who recorded the plant material grew on the hill tops were 26.7%. Some 19.2% of the respondents indicated that it grew on rocky areas while 10.8% indicated the species grew on farmland. Only 5% of the respondents indicated that it grew along rivers (Figure 4.1).

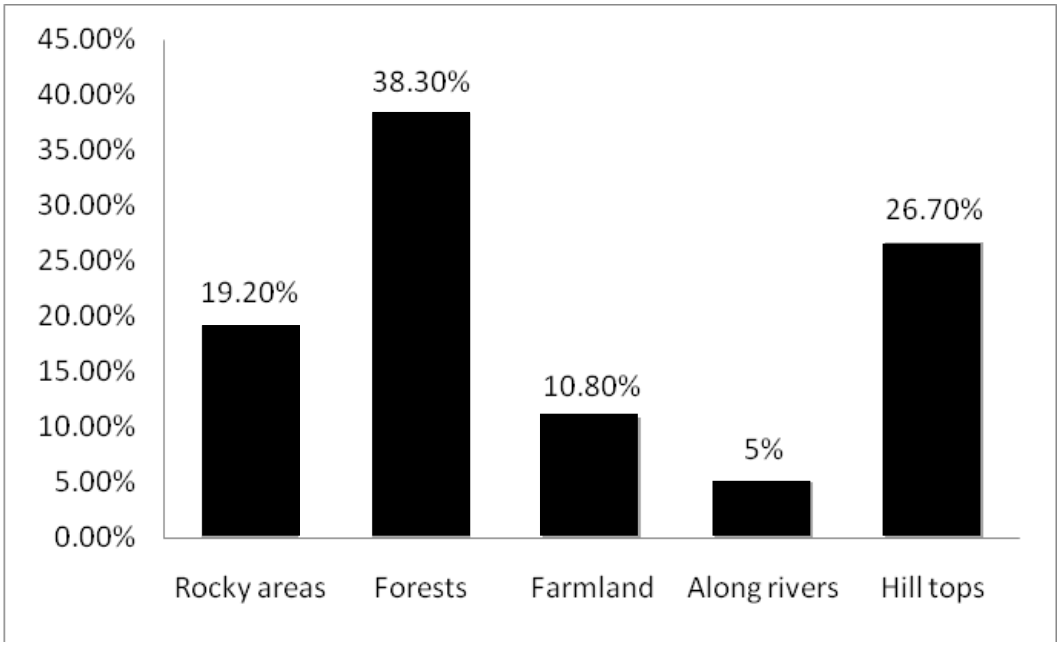

Figure 4.1: *O. lanceolata* growing habitats and ecosystems in the four targeted sub – counties in Kitui County.

4.2.2 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. There were higher populations of *O. lanceolata* in Endau hills in Kitui East Sub – County than other areas where the study was carried out. Locations in where *O. lanceolata* were found growing in Kitui Central Sub – County were Wikililye, Chuluni, Kavalula, Nzambani and Kyanika. Pearson correlation between distribution ($r = 0.666$ $p < 0.01$), with the harvesting trends of *O. lanceolata* from the wild was significant. Areas of Muthale, Musengo recorded the highest populations of O. lanceolata followed by the Endau, Wikililye and least populations were recorded in Mutomo and Mutha. Figure 4.2 shows distribution of *O. lanceolata* within the targeted study areas.

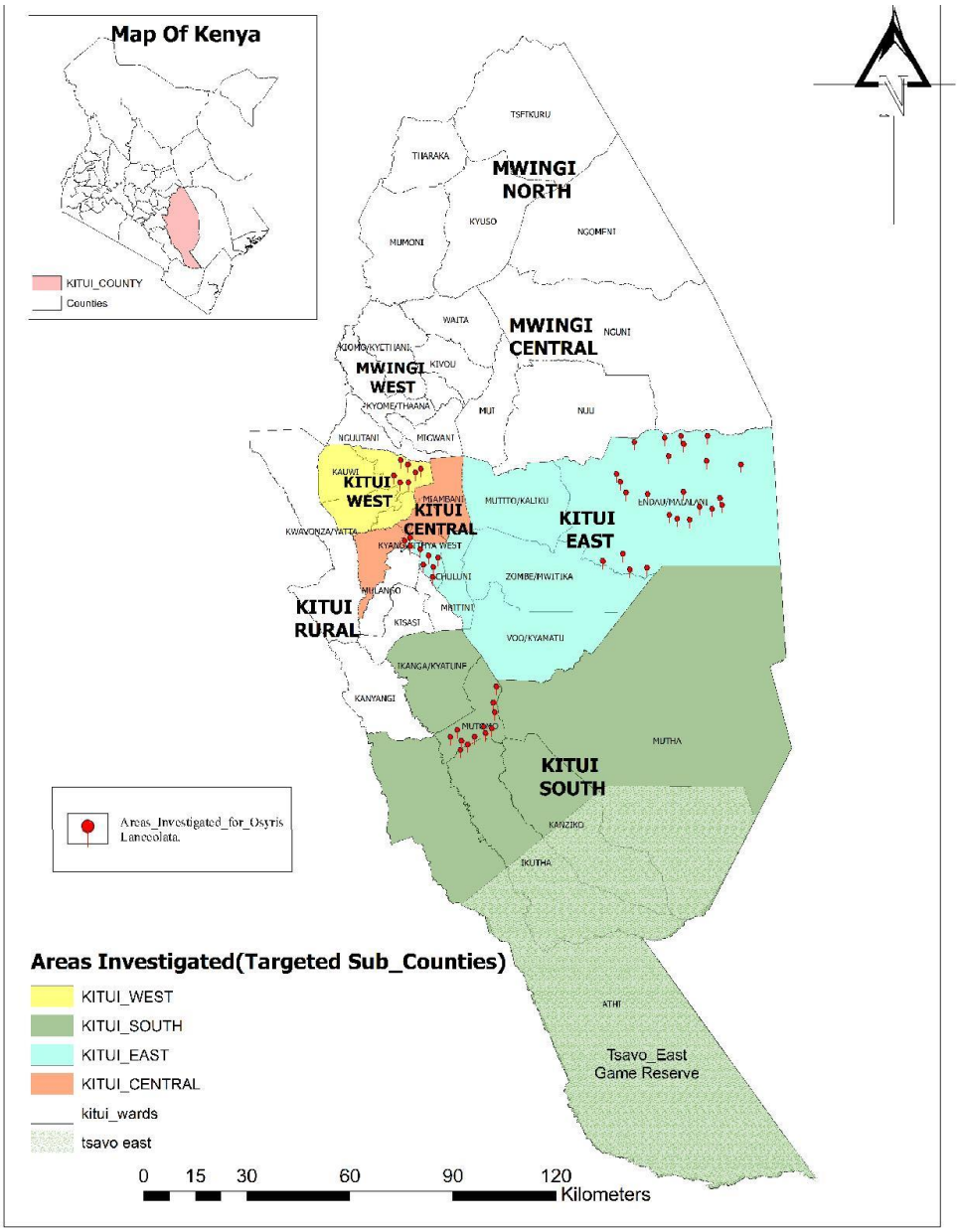

Figure 4.2: Distribution of *O. lanceolata* in the targeted study sub – counties in Kitui County

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

Another aim of this study was to evaluate the socio - economic benefits of *O. lanceolata* utilization in Kitui County. To achieve this objective the respondents' main sources of income, land sizes and use, livestock kept and marketing of *O. lanceolata* products were determined. The logistic regression results on socio – economic related factors the following factors were found significant (at $p < 0.05$) in influencing the *O. lanceolata* utilization: household income sources ($p = 0.036$); land sizes ($p = 0.047$).

4.3.1 Respondents' main sources of income

The respondents were requested to indicate their main sources of income. The categories included subsistence farming, livestock keeping, employment, casual laborer, businesses and relatives. The main source of income were subsistence farming 26.7%, livestock keeping 25% and employment 24.2% (Figure 4.3). This was followed by small businesses 12.5%. The least were those depending on relatives (3.3%) and others (1.7%).

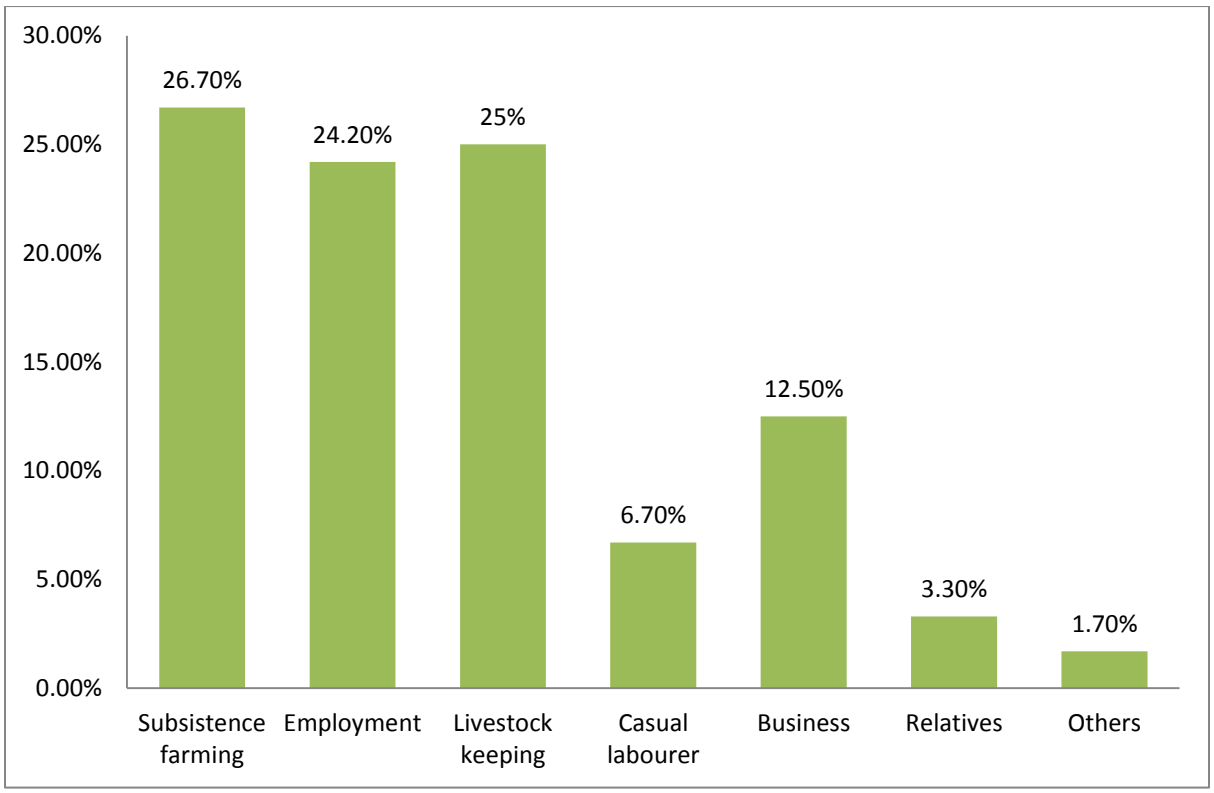

Figure 4.3: Respondents' main sources of income in the four targeted sub – counties in Kitui County

4.3.2 Land size and land use

Table 4.3 shows that majority of the respondents, 66.7% were using less than 2 acres of land with 89.2% of the respondents using it for tree planting and 87.5% for bee keeping. It was also revealed that the largest piece of land (14 – 16 acres, and above 16 acres) was fallow land (1.7%) and therefore used for grazing.

Table 4.3: Land sizes and utilization in the four targeted sub – counties in Kitui County

Land size in acres	Fallow F (%)	Bee keeping F (%)	Tree planting F (%)	Crops F (%)	Settlement F (%)	Mean F (%)	Std. Deviation
Less than 2	45(37.5)	105(87.5)	107(89.2)	32(26.7)	112(93.3)	80(66.7)	17.82
2 - 4	32(26.7)	10(8.3)	5(4.2)	79(65.8)	6(5.0)	26(21.7)	29.86
5 - 7	28(23.3)	5(4.2)	5(4.2)	4(3.4)	2(1.7)	9(7.3)	9.5
8 -10	17(14.2)	0(0.0)	3(2.5)	3(2.5)	0(0.0)	5 (3.8)	8.78
11 - 13	4(3.4)	0(0.0)	0(0%)	2(1.7)	0(0.0)	1(0.08)	2.0
14 - 16	2(1.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.08)	1.6
Above 16	2(1.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0.(0.0)	0.00

Figures in parenthesis are percentages of the respondents

Table 4.4 revealed that the highest land income for the respondents was from crop production with above Kshs 60, 0000.00 per year (6.8%). This was followed by income from fallow land of over Kshs 60,000.00 per year (6.8%). It was also established that tree planting had the lowest (85%) income of less than Kshs 10,000.00 per year followed by bee keeping (74.2%). The logistic regression results on income from the land ($p = 0.047$) was found significant (at $p < 0.05$) in influencing the *O. lanceolata* utilization in the study areas.

Table 4.4: Income from the land in the four targeted sub – counties in Kitui County

Income per year in '000/-	Fallow F (%)	Bee keeping F (%)	Tree planting F (%)	Crops F (%)	Mean F (%)	Std. Deviation
Less than 10	22(18.3)	89(74.2)	102(85.0)	10(8.3)	56(46.5)	57.8
10 -19	33(27.5)	20(16.6)	16(13.3)	15(12.5)		
					21(17.7)	1.72
20 - 29	28(23.3)	6(13.3)	2(1.7)	24(20.0)		
					15(12.5)	4.17
30 -39	12(10)	5(4.2)	0(0.0)	28(23.3)		
					11(9.4)	3.73
40 -49	10(8.3)	0(0.0)	0(0.0)	30(25)		
					10(8.3)	5.00
50 - 59	10(8.3)	0(0.0)	0(0.0)	5(4.2)		
					4 (3.1)	0.58
Above 60	5(4.2)	0(0.0)	0(0.0)	8(6.8)		
					4(3.1)	0.41

Figures in parenthesis are percentages of the respondents

From the logistic regression results in Table 4.5 below on the land size and utilization, the following factors were found to be significant ($p<0.05$) in influencing land utilization; fallow land ($p=0.000$), tree planting ($p=0.001$) and crop production ($p=0.002$). It was however established that bee keeping was not significantly ($p=0.841$) determined by land size.

Table 4.5: Regression results on land size and utilization

Variables	Unstandardized Coefficients	Standardized Coefficients		T - test	
	B	Std. error	Beta		
(Constant)	.212	.326		.652	.000*
1. Fallow	.129	.135	.185	5.416	.000*
2. Bee keeping	-.111	.538	-.101	-.206	.841*
3. Tree planting	.675	.489	.665	.358	.001*
4. Crop production	.788	.331	.749	.569	.002*

- Dependent variable: land utilization
- *Significant level at 0.05

4.3.3 Livestock kept

All the respondents kept less than 10 donkeys and sheep. This was followed by 80% of the respondents with less than 10 cattle. It was however established that there were more goats and poultry kept than the other livestock, with above 60 goats and poultry having 1.7% responses. Those with the highest number of cattle had 20 – 29 (3.4%) (Table 4.6).

There was a significant Pearson correlation between respondents who kept more livestock ($r = 0.712$, $p < 0.01$), with the harvesting and utilization trends of *O. lanceolata*.

Table 4.6: Livestock kept in the four targeted sub – counties in Kitui County

Number kept	Goats F (%)	Cattle F (%)	Sheep F (%)	Donkey F (%)	Poultry F (%)	Mean F (%)	Std. Deviation
Less than 10	40(33.3)	96(80.0)	120(100.0)	120(100.0)	15(12.5)	78(65.0)	23.7
10 -19	33(27.5)	20(16.6)	0(0.0)	0(0.0)	56(46.7)	22(18.2)	20.44
20 - 29	25(20.8)	4(3.4)	0(0.0)	0(0.0)	30(25.0)	12(9.8)	9.75
30 -39	13(10.8)	0(0.0)	0(0.0)	0(0.0)	11(9.2)	5(4.0)	7.0
40 -49	5(4.2)	0(0.0)	0(0.0)	0(0.0)	5(4.2)	2(1.6)	4.6
50 - 59	2(1.7)	0(0.0)	0(0.0)	0(0.0)	3(2.5)	1(0.8)	1.8
Above 60	2(1.7%)	0(0%)	0(0%)	0(0%)	2(1.7)	1(0.8)	1.0

Figures in parenthesis are percentages of the respondents

4.3.4 Income earned from the livestock

Table 4.7 below revealed that, majority (100%, 87.5% and 85%) of the respondents earned less than Kshs 10, 000.00 from sheep, donkeys and poultry respectively. It was however revealed that cattle keeping earned more income (Kshs. 50,000.000 – Kshs 59,000.00 and above Kshs 60,000.00) although not with a very big percentage (8.3%). This was followed by goats which had an income of above Kshs 60,000.00 (3.4%).

Table 4.7: Income sources from the livestock in the four targeted sub – counties in Kitui County

Income per year in '000/-	Goats Frequency (%)	Cattle Frequency (%)	Sheep Frequency (%)	Donkey Frequency (%)	Poultry Frequency (%)	Mean F (%)	Std. Deviation
Less than 10	25(20.8)	5(4.2)	120(100)	105(87.5)	102(85.0)	71(60.0)	30.96
10 -19	28(23.3)	17(14.2)	0(0.0)	15(12.5)	16(13.3)	15(12.6)	5.32
20 - 29	40(43.3)	28(23.3)	0(0.0)	0(0.0)	2(1.7)	14(11.7)	10.6
30 -39	9(7.5)	39(32.5)	0(0.0)	0(0.0)	0(0.0)	10(8.3)	2.28
40 -49	2(1.7)	16(13.3)	0(0.0)	0(0.0)	0(0.0)	4(3.0)	12.25
50 - 59	2(1.7)	10(8.3)	0(0.0)	0(0.0)	0(0.0)	2(1.6)	7.6
Above 60	4(3.4)	10(8.3)	0(0.0)	0(0.0)	0(0.0)	2(1.6)	7.6

Figures in parenthesis are percentages of the respondents

4.3.5 Sources of skills for *O. lanceolata* harvesting

Majority of the respondents (48.3%) had obtained the harvesting skills for *O. lanceolata* from trainings. Those who acquired it by observing neighbours harvesting it were 20.8%. Others got it through observing neighbours (20.8%). The least are those who acquired skills from family (16.7%), dealers (13.3%) and other sources (0.8%).

Table 4.8: Sources of skills for harvesting *O. lanceolata* in the four targeted sub – counties in Kitui County

Source	Frequency	Percent
Family	20	16.7
Training (specify)	58	48.3
Neighbours	25	20.8
Dealers	16	13.3
Others	1	0.8
Total	120	100.0

4.3.6 Main purpose for *O. lanceolata* harvesting

The main purpose for harvesting *O. lanceolata* was for sale to earn income. This was reported by (44.2%) of the respondents. Those respondents who reported the main purpose of harvesting *O. lanceolata* for both commercial and local use were 39.2%. Local use only was done by 16.7% of the respondents.

4.3.7 Major beneficiaries of *O. lanceolata* business

The major beneficiaries *O. lanceolata* business were the manufacturers (45%). Further, 30% of the respondents reported that middlemen benefited. The local communities who were harvesters only benefited by 17.5% while it was reported that the transporters benefited by 5.8%.

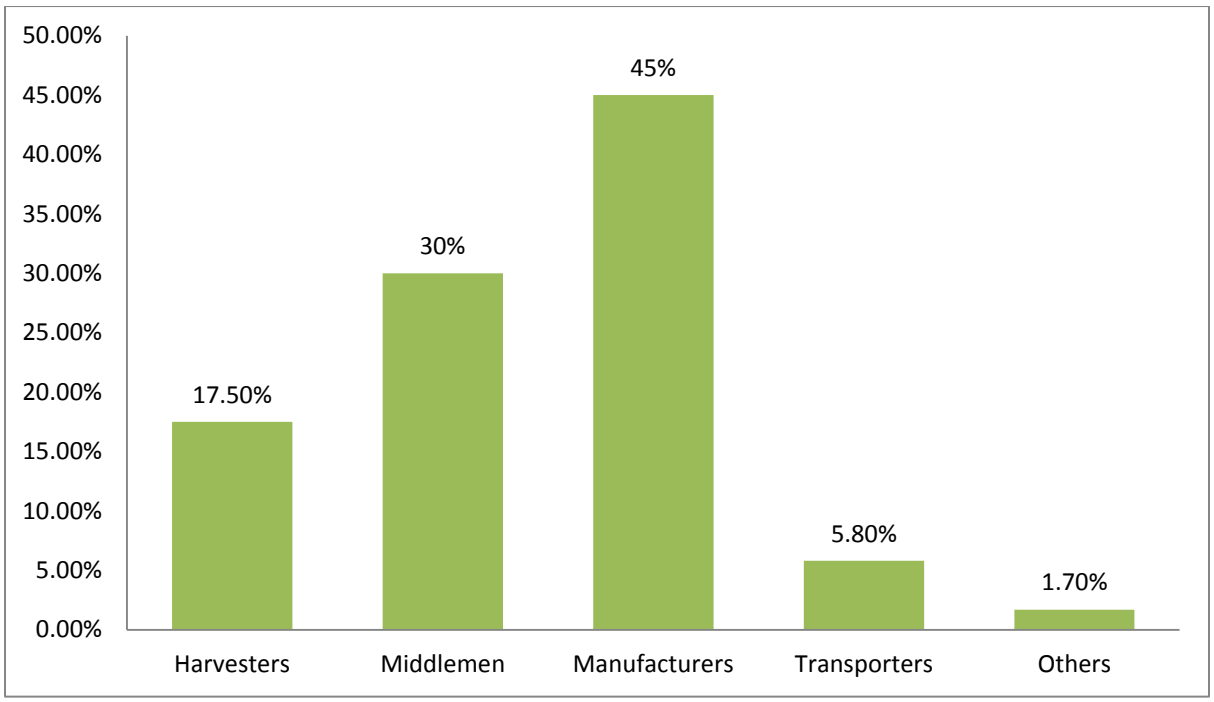

Figure 4.4: *O. lanceolata* plant business beneficiaries in the four targeted sub – counties in Kitui County

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

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

In Kitui County, incidences of illegal harvesting of *O. lanceolata* have been reported for the last five years. The study established that one litre of the refined and processed *O. lanceolata* oil price costs Kshs. 90,000.00.

4.4.9 Main *O. lanceolata* customers

Majority of the respondents (51.7%) reported that the main customers for *O. lanceolata* were the companies which manufacture pharmaceutical products and 29.2% were companies which manufacture cosmetics products (Table 4.9).

Table 4.9: Main customers of *O. lanceolata* products in the four targeted sub – counties in Kitui County

	Frequency	Percent
Permaceutical Companies	62	51.7
Cosmetics Companies	35	29.2
Food industry	3	2.5
Clothing	2	1.7
Middlemen	18	15.0
Total	120	100.0

4.4.10 *O. lanceolata* major uses

The major use *O. lanceolata* was reported to be for medicinal production according to the respondents (64.2%). Oil production was reported at 25.8%, firewood utilization was reported at 5.0%, wood carving was reported at 2.5% and construction reported at 1.7%.

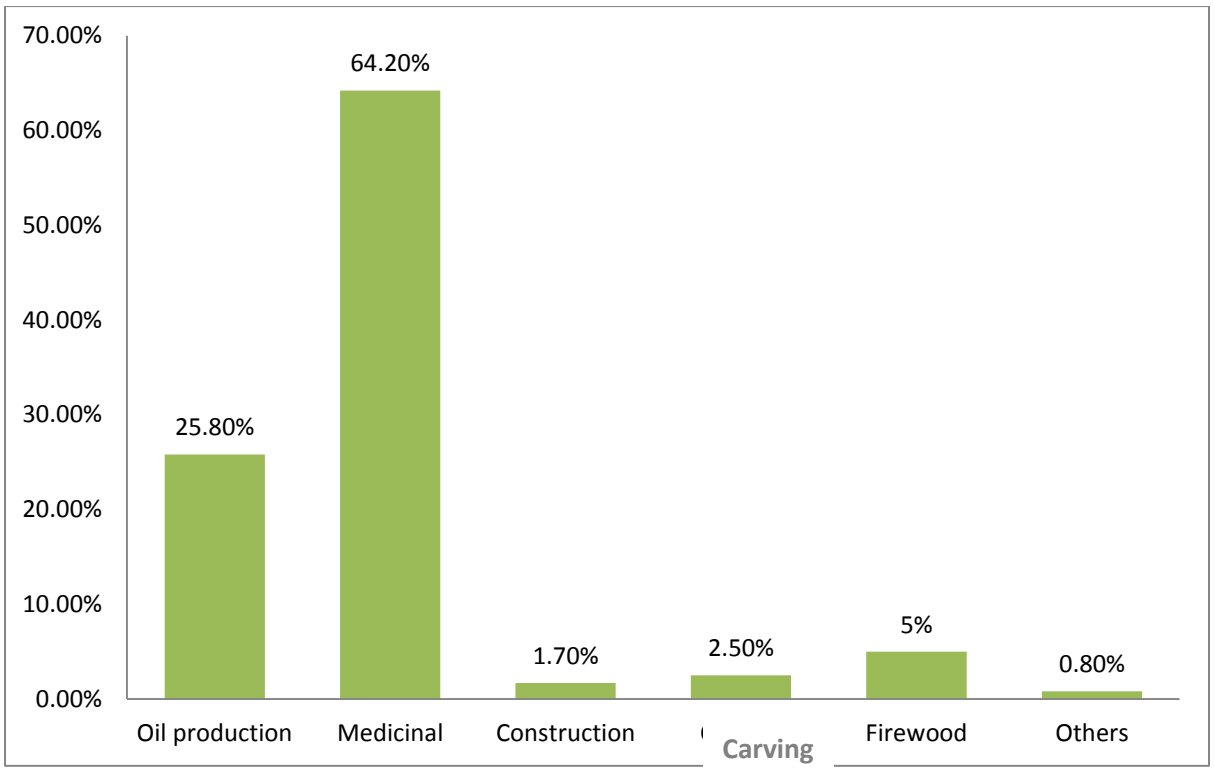

Figure 4.5: *O. lanceolata* major uses in the four targeted sub – counties in Kitui County

4.5.0 Environmental impacts of exploiting *O. lanceolata* plant species

4.5.1 Methods of harvesting *O. lanceolata*

The third objective for this study was to ascertain the environmental impacts associated with exploitation of the *O. lanceolata* plant species in Kitui County. Most of the interviewees (73.3%) reported that the main method for harvesting *O. lanceolata* was by total uprooting.

Respondents reported that selective and branch harvesting was reported at (10.8%), debarking at 3.3% and leaf harvesting (1.7%). Most of the interviewees (42.5%) reported that *O. lanceolata* oil was mostly concentrated within the plant root system and thus were the heavily uprooted in order to provide much needed demand for the plant material. Both stem and roots were reported by respondents at (25%), stem alone at (18.3%), leaves at 9.2% and branches at 5.0%.

Table 4.10: Methods used in harvesting *O. lanceolata* in the four targeted sub – counties in Kitui County

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**

4.5.2 Major environmental degradation effects caused by exploitation of *O. lanceolata*

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 4.11).

Table 4.11: Environmental degradation consequences caused by exploitation of *O. lanceolata* in the four targeted sub – counties in Kitui County

	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**

4.5.3 Existing legal and institutional framework

The fourth objective was to determine the legal framework associated with *O. lanceolata* utilization in Kitui County. The data on existing legal and institutional framework was obtained from the key informants and resource persons from both government institutions and Non – Governmental Organizations. On the existing legal and institutional framework majority of the respondents 82% were not aware of any existing regulations governing conservation and management of *O. lanceolata*. Most of the respondents 67% reported that the government should be the one in charge of enforcing any regulations and guidelines on conservation and management of *O. lanceolata*. 74% of the respondents reported that Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) if implemented was best placed to conserve and protect *O. lanceolata* in Kitui County. About 53% of the respondents reported that there was a gap on the way forest resource management was done amongst the existing institutions in Kitui County. Only 17% reported that the Forest Conservation and Management Act, 2016 should be implemented in order to ensure sustainable conservation and utilization of the *O. lanceolata*. At least 45% of the respondents

reported that sustainable conservation and management of *O. lanceolata* initiatives should be carried out by the government institutions, while 30% of the respondents felt that conservation should be done by the individual farmers where the plant species grow. Only 16.7% reported that the conservation work should be done by the non – state actors such as NGOs and religious groups. Only 8.3% felt that the management of the species should be trusted with the local communities and organized community groups.

At least 47% of the respondents reported that organized community groups and people neighboring where *O. lanceolata* grows should be empowered to carry out the enforcement and compliance sustainable management and utilization of the *O. lanceolata*.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Demographic information

Most of the respondents were men during the interview. This was because the study was looking at a very sensitive plant species with very high economic value and thus more men than women interviewees were interested to participate in the discussions. This was in agreement with Mogaga (2001) who found that men are more interested in the discussions revolving on income generation and community livelihood enhancement. Gender was found to be a significant factor in determining awareness and utilization of *O. lanceolata* utilization in the study area ($p < 0.05$). As was observed by Helmstadler, (2009) the study confirmed more males were aware and involved in *O. lanceolata* utilization than females. Ochanda, (2011) showed that most of *O. lanceolata* was poached at night due to high demand for the provision of raw materials in the pharmaceutical and cosmetic producing industries. Similar findings were also reported by Karanja, (2012), that males were more interested and have more power to make decisions regarding the sources of income for the households. In Kitui Central and Kitui West Sub-Counties most of the respondents were aware of the unsustainable harvesting of *O. lanceolata* plant materials and this could be due to accessibility of the transportation of the *O. lanceolata* products to major urban centres of Nairobi and Mombasa cities.

5.2 *O. lanceolata* distribution and mapping

As documented by Machua *et al.,* (2009), much of the distributions of *O. lanceolata* were established to grow in less fertile soils whose altitudes were higher than 1,000 metres above the sea level. Domestication and on – farm growing of *O. lanceolata* can be done by farmers in the study area since there has been ever a need to have alternative livelihoods for the communities in ASALs especially during the dry season to innovate sustainable livelihood sources. Sustainable conservation of the existing natural forests and re-afforestation of the degraded habitats have been highly recommended by KFS, (2010) so that *O. lanceolata* gets more plants to associate with as they grow. Most respondents were aware of the other plant species that grew together with *O. lanceolata* as was also confirmed by Mukonyi *et al*, (2011) who found out that most of the rural populations in Kenya depend on the herbal medicine. It

was established that most of the *O. lanceolata* plant material grew on ungazetted and private forests KFS, (2010). In the surveyed study sites it was established that *O. lanceolata* grew in both gazetted and ungazetted forests. The only gazetted site the plant material was found to grow was in Endau forest in Kitui East Sub – County. The enforcement of the existing regulations on *O. lanceolata* harvesting has not been effectively implemented since most of the areas where *O. lanceolata* grows are not protected or gazetted. There exists challenges in the prosecution of the culprits in possession of the illegal *O. lanceolata* plant materials. Even in gazetted forests such as Endau forest there has been rampant harvesting of *O. lanceolata* and respondents have not been involved the sustainable management and conservation . In Kitui Central and Kitui West Sub – Counties which are accessible to main road to major urban centres of Nairobi and Mombasa high incidences of *O. lanceolata* illegal harvesting were reported.

The study established that *O. lanceolata* plant materials had been growing within the study area for a long time and the plant material has been well known to the local communities. Traditionally local communities' known uses of *O. lanceolata* have been only source of medicine and firewood. 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). Machua and his team reported that massive exploitation of *O. lanceolata* started in Tanzania and when *O. lanceolata* populations became too few, the exploitation spilled over to Kenya and other regions.

5.3 Socio – economic benefits of harvesting *O. lanceolata*

Majority of the interviewees had attained basic primary education and thus had low income levels. As a result of lack of higher level of education the study established that the respondents could not compete favorably with other members of the community and thus this could be the reason why most of them were mainly relying on subsistence farming as main source of income for their livelihoods. Nyerere (2000) in his report confirmed that majority of the people living in rural areas depend on farming and small businesses for their survival. The low production levels revealed in the results could mean that the communities living within the study area were experiencing negative effects such as prolonged droughts leading to crop failures, livestock deaths and lost opportunities. All these factors could have led to

the increased harvesting of *O. lanceolata* in order to provide communities with alternative sources of livelihood. Same findings were also ascertained by Beentje, (1994). Beentje in his studies reported that majority of people in rural areas depend on the fragile and declining natural resources to derive their livelihoods. The F-statistics at ($F = 74.619$) there was statistically significant relationship between *O. lanceolata* harvesting and socio – economic variables which consisted of level of education, age, income levels and usage knowledge of the *O. lanceolata*, occupation and land size of the respondents ($p< 0.05$). A study in the Chyulu Hills in Kenya showed that locals used *O. lanceolata* for commercial and medicinal purposes (Ochanda, 2011).

Majority of the interviewees were married and aged between 30 – 39 years. This means that most of the respondents were in the most productive age bracket. This is in accordance to Helmstadler, (2009). Helmstadler reported that young and unemployed human population in rural areas in developing countries depend on forestry and allied natural resources to make a living. As a result of not being formally employed majority of the respondents could have turned to the harvesting and trading of *O. lanceolata* in order to earn income. This was further supported by the fact that most of the respondents owned less than two acres of land meaning that they could not carry out meaningful farming activities. More poultry and goats were kept than any other livestock and this could be due to cost involved in their management. Most of the households earned less than Kshs. 10,000 from these livestock kept and thus these households were forced to look for alternative sources of income. Land size utilization was found significant ($p < 0.05$) in influencing and determining the economic status of the household. These findings were supported by Ochanda, (2011) who established that within Chyulu hills in Makueni County, most of the communities neighboring the forest carry out illegal *O. lanceolata* harvesting to complement their meagre incomes. People neighboring Chyulu National Park earned Kshs. 4.00 to Kshs. 7.00 for every one Kilogram of harvested *O. lanceolata* while the brokers sold the same one Kilogram of harvested *O. lanceolata* at Kshs. 80.00 per kilo. In the global trade, 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 (KFS, 2009).

Cattle rearing and animal husbandry gave the respondents highest income of Kshs. 60,000 per year than other land use practices. This was a small margin indicating that there was still need for more income from other land uses hence people opted for the alternative sources of income including *O. lanceolata* illegal harvesting in order to complement their little income. This study confirmed findings by the UNEP annual report (UNEP, 2012) that forests and allied resources utilization contribute 3.6% to the GDP excluding environmental services and contributions to other sectors.

Majority of the respondents felt and believed that they were not benefitting from the harvesting and trade of *O. lanceolata*. Instead they believed it was transporters, brokers and manufacturers who benefitted highly from the trade. Majority of the respondents had no idea where the harvested material was taken to and how they were processed to produce finished products. Processing of *O. lanceolata* into finished usable products requires technology and machinery and since most of the respondents had minimal level of education that is why they could not bargain for a fairer share during the harvesting and trading *O. lanceolata* products. 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 roots, heartwood, timber for handicrafts and leaves used as medicine. Much of the essential oil deposits are concentrated in the plant root system (Machua *et al*., 2009).

5.4 Environmental impacts associated with *O. lanceolata* harvesting

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* occurred. Majority of the interviewees 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 threatening its natural existence. During the study, it was found that environmental degradation associated with unsustainable harvesting

of *O. lanceolata* was degradation of water catchment areas. Hence as a consequence has increased soil erosion and environmental degradation, this is in accordance to Kieti *et al*, 2016. Kieti in his studies reported that watershed and catchment ecosystems once are disturbed, they cease to supply essential ecological goods and services. Due to illegal harvesting, most of the mature trees have been removed from the wild (Chene, 2005). Total uprooting of the *O. lanceolata* plant was the common method of exploitation as similarly confirmed by Ochanda, (2011). Majority of the harvesters targeted *O. lanceolata* root system since they fetched higher prices than other parts of the plant. Harvesting of plant root system is not sustainable since once root system is interfered with the plant can no longer exist. *O. lanceolata* is one of the very few plants globally whose propagation has been difficulty, this means the very few plant populations which germinate and grow to become mature plants should be well managed and conserved in order to provide ecological goods and services to the community FAO, (2015). Generally environmental degradation brings reduction in agricultural crops production, loss of soil fertility, increased poverty amongst people and loss of livelihoods Mary, (2015).

5.5 Legal framework associated with *O. lanceolata* harvesting

In Kenya, according to the Kenya Law Gazette Notice, (2007) *O. lanceolata* harvesting was banned for a period of five years in order to allow for the development of sustainable harvesting mechanisms (Walker, 2006). Currently Kenya does not have regulations and guidelines on how to promote *in – situ* conservation of *O. lanceolata* either through the domestication of the plant species or by any other means. 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 main cause for the ever increasing of the illegal trade of the O. lanceolata associated products (Mary, 2015).

Respondents reported to have been trained on the identification, management and uses of the *O. lanceolata* and sustainable harvesting. This was recorded in Kitui West and Kitui Central sub – counties. During focused groups' discussion meetings, it was observed that the participants from the two sub – counties had already started establishing individual and community conservation areas for the protection of *O. lanceolata*. This is in accordance to

the IUCN (2001) which highly recommends establishment and management of community conservation areas. East Africa countries developed a species assessment and monitoring protocols that are aimed at leading to the establishment of certification measures for sustainable harvesting of *O. lanceolata*. According to (UNEP, 2012) East Africa countries research programmes in order to establish baseline for *O. lanceolata* populations and projected future demands so that enough data and information can be generated to guide policy making and decision making for sustainable development. Key findings generated so far shows that currently, significant sub populations of the species in the two countries exist in the protected areas, while most of the specimens harvested illegally have been from non – protected areas.

5.6 Relationship between *O. lanceolata* utilization and independent variables

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, that is *O. lanceolata* utilization with socio - economic benefits having the highest correlation of ($r=0.781$, $p< 0.01$) followed by the usage knowledge with a correlation of ($r=0.744$, $p< 0.01$) and then distribution of *O. lanceolata* with a correlation of ($r=0.666$ $p< 0.01$), with environmental impacts with the least correlation of ($r= 0.581$, $p< 0.01$). This showed that all the variables under consideration had a positive relationship with the dependent variable. According to the 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; 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.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In this study, it was established that most of the *O. lanceolata* wild populations were mapped to occur in Endau, Mutonguni, Chuluni and Mutha. Most of the interviewees who had received either formal or informal education knew the uses of the *O. lanceolata* products. Illiterate interviewees did not know the uses of the *O. lanceolata*.

Majority of the people who got in the business of harvesting *O. lanceolata* in Kitui County did so in order to enhance their income levels for improved livelihoods. 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 thus this meant that it was a new business.

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.

The study established that there is weak enforcement on the existing legislations aimed at conserving *O. lanceolata* in the country.

6.2 Recommendations

1. From the data analysis it has been established that *O. lanceolata* grows in the forests and hill tops and thus there should be efforts to protect and conserve these natural ecosystems in order to ensure sound conservation of this important plant resource. According to the Kamba taboos and customs, *O. lanceolata* was not supposed to be used for firewood and such kind of beliefs should be promoted for they help in the conservation of the *O. lanceolata* in the country.

2. There is need to institute low-cost methodology of monitoring the propagation and population status of *O. lanceolata* wild populations. The approach could involve the participation of the local community representatives working closely with government research institutions and authorities to provide detailed and long-term data.

3. Communities and interested stakeholders should be supported to domesticate *O. lanceolata* in their farms and be assisted to get ready market for the plant materials since the demand for the plant material is very high both for local and international markets. Such community members should be encouraged and supported to form user groups whereby value addition, processing and packaging of the *O. lanceolata* materials should be done in order to improve community livelihoods. This can be achieved through the support of the establishment of cottage industries so that high value products are produced.

4. Most of the *O. lanceolata* grows in community and government forests and other natural forests thus there should be concerted efforts to ensure all the natural forests in the county are under appropriate management practices so that incidences of illegal harvesting of the *Osyris lanceolata* can be curbed. Government agencies should intervene and develop regulations to control the business in order to ensure there is sustainability.

5. Government institutions and especially Kenya Forest Service, Kenya Forestry Research Institute and National Environment Management Authority, non-state actors and community organizations should work closely with the Kenya Police Service and other law enforcement authorities to ensure environmental laws are properly enforced in order to reduce unsustainable harvesting, illegal poaching and trade in *O. lanceolata* in the Kitui country.

6. The Government should recognize the need for tax and fiscal incentives that could be granted to various community groups and individual farmers as a means of motivating them to engage in the in – situ management of the *O. lanceolata*. Activities that could benefit from tax and fiscal incentives could include the increase of investments in forest use and forest resources utilization.

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APPENDICES

Appendix 1: Questionnaire on socio – economic status of households

There has been rampant harvesting of *Osyris lanceolata* in Kitui County owing to the high demand associated with *Osyris lanceolata* products both nationally and globally. Mr. Dominic M. Mumbu a Master's degree student in Environmental Management at South Eastern Kenya University (SEKU) is carrying out a study on, *"Assessing the Utilization and Socio – economic benefits of Osyris lanceolata and Associated Environmental Degradation Impacts in Kitui County"*. This questionnaire aims at analyzing the contribution of *Osyris lanceolata* utilization along the market chain to the livelihood improvement of the local people in the study area. The information obtained will be analyzed and used in developing sustainable *Osyris lanceolata* propagation, harvesting guidelines techniques and inform policy. The information you provide will ensure the realization of the set goal. You are encouraged to stay assured that the information provided is for research purpose and it will be kept confidential.

For official Use only

Questionnaire No.	
Name of Interviewer/Enumerator	
Phone Number	
Date	

SECTION A: GENERAL INFORMATION

GPS Coordinates: Longitude:…… Latitude: ……..

1. Respondent's name (Optional)……..……...

2. County: …… 3. Sub-county: ……

4. Ward: …… 5. Nearest Market Centre: …….....

6. Location: …… 7. Sub-location: …….

8. Village: ……

9.Gender

1=Male…….2=Female……

10.Age

1= 18-35yrs……..2= 36-50yrs…….3= 51-70……..4=>71yrs ……

11.Level of education

1=Primary……2=Secondary……2=College……4=University……5=None……

12. Marital status

1=Married (Monogamous) ….2=Married (Polygamous)……3=Single…4=Divorced……

13. Religion

1=Catholic…2=Protestant…3= Muslim….4= Traditionalist…

4= None…

14. What is the family's main source(s) of income/livelihood? (*Tick all mentioned*)

1=Farming (subsistence)…….. 4=Employment (salaried)……. 2=Livestock rearing……. 5=Casual labor wages……. 3=Small scale business/Petty trade……. 6=Remission from working relatives…….. 7=Cash in Kind…… 8=Others (Specify)……..

SECTION B: ECONOMIC ACTIVITIES

15. What is the total size of your land? _____

16. What is the size of your land under different land use systems?

Land use	**Size (acres)**	**Income (Kshs) p.a.**	**Remarks**
Fallow/grazing land			
Bee keeping (**Number of**			

hives)			
Tree planting			
Crops			
Settlement/Compound			
Seedlings sales			

17. Which other off-farm economic activities are you involved in?

Activity	**Income (Kshs) p.a.**	**Remarks**

18. State the type and number of livestock kept?

Type	**Number**	**Income (Kshs) p.a.**
Cattle		
Goats		
Sheep		
Donkey		
Poultry		

19. Sate the types of agricultural crops grown?

Type of crop	**Yield/year**	**Income (Kshs) p.a.**

20. State the main tree species found growing on the farm?

Species	**Number**	**Main use**	**Income (Kshs) p.a.**

21. State the main types of fruit trees grown on your farm?

Type	**Number**	**Income (Kshs) p.a.**

SECTION C: SANDLEWOOD HARVESTING

22. Do you know sandalwood (*Munyungamai*) plant? 1=Yes_____2=No_____

23. Are you aware of sandalwood harvesting in this area? 1= Yes _____2= No _____

24. Are you aware of any community association dealing with sandalwood harvesting in this area? 1=Yes___2= No

25. If yes what do think prompted the formation of the association? _____

26. If the association exists do you think it is legal or illegal? 1= legal 2=illegal Give brief explanation _____

27. Is there well laid down by-laws governing the day to day running of the association? 1=Yes _____ 2=No _____

If Yes, briefly explain._____

28. For what purpose do you think Sandalwood is harvested for?

Purpose	**Tick**	**Remarks**
Income / commercial		
Domestic / local use		
Both		

29. Where do you think those who are involved in sandalwood harvesting acquired skills / information from?

1=Self-Family ___ 2=Training (specify) ___ 3=Neighbors' ___ 4=Dealers___5=Other (specify) _____

30. (a). Which part of the sandalwood plant is harvested?

Part	**Tick**	**Remarks**
Stem		
Roots		
Both stem & roots		
Leaves		
Branches		
Other (specify)		

(b). How frequent do you think sandalwood is harvested in this locality? (Tick appropriately and indicate the number of times).

Period	**Tick**	**Remarks**
Weekly		
Fortnightly		
Monthly		
Other (specify)		

(c). How many people do think are involved in the process of harvesting sandalwood from this area?

Number	**Tick**	**Remarks**
1 - 5		
5 - 10		
10 - 20		
➢ 20		

31. i. Is the sandalwood harvested from the whole tree or part of tree? 1=whole___ 2=part of tree_____

ii. What do you think sandalwood is used for? (Please tick)
1=oil___ production____2=medicinal____3=Construction____4=Carvings_____
5=Firewood _____ 6=others (specify) _____

iii. What do you think is price locally per kg of Sandalwood in Kshs._____

iv. How much is casual paid per day for harvesting sandalwood in Kshs_____

SECTION D: MARKETING OF SANDALWOOD PRODUCTS

32. i. Do you know who owns the sandalwood business in Kenya?1=Yes__ No___

ii. Where do you think the Sandalwood bought is taken to?

_____

iii. How many years has sandalwood harvesting undertaken from this locality? 1=less 1 year 2=2- 4 years, 3=4 – 7 years, 5= > 7 years

iv. What do think motivates people to join this activity/business? (Please tick)

1=Profit__2=Good payment__3=Availability of Sandalwood__4=Other (specify) _____

33. How do you think sandalwood is packaged and priced? (Tick below and indicate the sell price and the number of units you sell per month indicating the highest and lowest selling price in the past year).

Packaging unit	**Number of bags sold per month**	**Minimum current selling price per bag**	**Maximum current selling price per bag (Kshs)**

		(Kshs)	
Small bags (50 kg)			
Large bags (90 kg)			
Other (specify)			

34. What determines the selling price of the Sandalwood?

Factor	**Tick**	**Remarks**
Self		
Market forces		
Buyers		
Season		
Other (specify)		

35. Who do you think are MAIN customers / clients for sandalwood?

Customer	**Tick**	**Remarks**
Pharmaceutical Companies		
Perfume / cosmetics industry		
Food industry		
Clothing / dye industry		
Middlemen		
Other (specify)		

36. In your own opinion, who are the main beneficiaries of the Sandalwood business in Kitui County? Briefly explain your answer:

1=Harvesters____2=Middlemen__ 3=Manufacturers___4=Transporters 5=Others___

Give brief explanation_____

_____

_____

37. Is the money earned from the sandalwood harvesting ploughed back into the development activities of this area? 1=Yes____2= No ___

If yes briefly explain?

_____

_____

SECTION E: LEGAL AND INSTITUTIONAL FRAMEWORK

38. Do you know ANY laws/regulations that govern Sandalwood harvesting and trade in Kenya? 1=Yes___2=No___ If Yes, what does the law say?

    _____

    _____

39. What arm of the government is enforcing these laws?

Department	**Tick**	**Remarks**
National Government Institutions (KFS,KWS, NPS etc)		
Community policing		
County Government of Kitui		
Others (Specify)		

40. In your opinion, who are best placed to enforce these laws? _____

_____

41. What kind of permit do think can be required to harvest and market sandalwood in Kenya? 1=Authority to harvest trees___2= Movement permit ___3_other (specify)_____

SECTION F: SANDALWOOD AND HVMTS CONSERVATION

42. Which ecosystems do you think sandalwood grow on?

1= Rocky / infertile areas 2=Forest___ 3= Farmland____4=along rivers____ 5=Hill tops___ 6=Others (Please specify) _____

43. What is the existing ownership status on where sandalwood grow? (Tick appropriately)

Source	**Tick**	**Remarks**
Own / farm land		
Neighbors' land		
Government forest		
Communal land		
Other (specify)		

44. Which tree species do you think grow in association with Sandalwood (Please mention plant / tree species in vernacular).

No.	**Plant species mentioned in vernacular**	**Botanical name of the plant species**
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

45. i. Do you how sandalwood plant is propagated? 1=Yes____2=No _____

ii. IF YES, what are the existing propagation methods?

1=use of seeds____2=use of cuttings_____ 3=by grafting/marcoting____4=by use of wildings 5=Others (specify) _____

46. Are you aware of any organization which has tried to conserve sandalwood in Kitui County 1=Yes___2=No___If yes which organizations_____

_____

47. What methods do you think are used in harvesting sandalwood?

1=Total Uprooting____ 2=Selective harvesting____ 3=branch harvesting___4= debarking____ 5=Leaf harvesting_____ 6=Others (Please specify) _____

SECTION G: HIGH VALUE MULTIPURPOSE TREES AND SHRUBS

48. In order of priority, list at least ten major tree/shrub species that you know and indicate sale details where possible.

***Examples of end uses:** Oil (OL)**,** Medicine (MD), Fruit or Food (FF), Poles (PO), Fuel Wood(FW), Timber (TM), Animal Fodder(AF), Soil Improvement (fertility) [SI], Soil erosion control (SE), Shade(SH), Timber (TM), Essential oil (EO), Fibre (FB), Dye (DE)

Local name	**Part used**	***End uses**	**Product/Service derived**	**Form extracted (1=Crude; 2=Value added-specify)**	**Purpose (1=Domestic; 2=Commercial**	**Where sold**	**Price/unit**	**Rarity status (1=Highly available; 2=Slightly available; 3=Rare)**

2. From the above, name the HVMTs/Shrubs which you think are currently over-exploited from the wild

_____

49. What could be the reasons for over-exploitation of these HVMTs/Shrubs?1=Local use____2=Commercial use____ 3=Cultural/spiritual____ 4=Others (Please specify)_____

50. What environmental degradation consequences have been caused by over-exploitation of the mentioned species?

1= Drop in crop production_____ 2=Increased soil erosion_____ 3=Lack of fodder for livestock_____ 4=Diminishing of Water resources_____ 5=Others (Specify)_____

51. Do you cultivate any of the High value multi-purpose trees/shrub species mentioned above?

1=Yes_____ 2=No_____

52. If yes, please name them

_____

_____

53. State some of the challenges that you encounter in cultivating the HVMT/Shrubs

1=Water shortage___ 2=Insects / pests____3=Lack of tree seedlings____ 4=Lack of information on right species____5= Lack of planting technology_____6=Low germination/Seed dormancy____7=Others (Specify) _____

54. Suggest methods of conserving HVMTS in Kitui County.

_____

_____

_____

55. What general comments would you give in regard to HVMTS production and trade in Kitui County:

_____

_____

56. Would you like to be contacted again for further discussion on HVMTS and sandalwood harvesting and trade? Yes ____No ____ If, Yes please give us your contact:

    Name_____

    Tel_____P.O. Box_____

Enumerators Comments _____

_____

Thank you for your kind co-operation and collaboration with us!

Appendix 11: Questionnaire on information from key informants for *Osyris lanceolata* (sandalwood) survey in Kitui County

There has been rampant harvesting of Osyris lanceolata (Sandalwood) in Kitui County owing to the high demand associated with *Osyris lanceolata* products both nationally and globally. Mr. Dominic M. Mumbu a Master's degree student in Environmental Management at South Eastern Kenya University (SEKU) is carrying out a study on, *"Assessing the Utilization and Socio – economic benefits of Osyris lanceolata and Associated Environmental Degradation Impacts in Kitui County"*. This questionnaire aims at analyzing the contribution of *Osyris lanceolata* utilization along the market chain to the livelihood improvement of the local people in the study area. The information obtained shall be analyzed and used in developing sustainable *Osyris lanceolata* sustainable harvesting guidelines techniques, conservation, management and inform policy. The information you provide will ensure the realization of the set goal. You are encouraged to stay assured that the information provided is for research purpose and it will be kept confidential.

A. **GENERAL INFORMATION**

A1. Name of the Institution / Organization / Department / Business: ……

A2. Physical Address:

Building:……..…Street……Floor/Room……..

A3. Postal Address: P.O Box…… Code……..Town……..……

Tel.....Email.....Web.....

A4. Contact Person: Name……..……Tel….....

Email…….....

A5. Designation: .....

A6. Age: .....

A7. Gender: .....

A8. Highest level of education: .....

A9. Number of years in service: .....

A10. What type is your Institution / Organization / Department / Business?

.....

.....

.....

A11. What are the core functions/services/products of your organization/Business?

.....

.....

.....

.....

B. SANDALWOOD CONSERVATION AND MANAGEMENT STATUS

B1. (a) Are you aware of the Sandalwood growing in Kitui County? i) Yes.....ii) No.....

(b) If yes where does Sandalwood known to grow in Kitui County?

……

……

……

……

……

(c) Is your Organization involved in the conservation and management of Sandalwood?

i) Yes…….ii) No……..

ii) If yes what is being done?.....

……

……

……

……

…….

B2 (a) Do you involve community and other stakeholders participation in the implementation of your core activities in your organization?

i) Yes.....ii) No.....

(b) If yes, please state what it entails

.....
.....
.....
.....
.....
.....
.....
.....

(c) Please can you explain the level of involvement for each stakeholder you engage?

Stakeholder Level of involvement

B3. (a) Does your organization, Business include indigenous knowledge in management decisions regarding conservation and management of Sandalwood in Kitui County?

ii) Yes.....ii) No.....

(b) If yes, what are the indigenous knowledge skills you use in the advancement, conservation and management of Sandalwood in Kitui County?

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B4. (a) Are there environmental degradation impacts associated with Sandalwood harvesting in Kitui County?

i) Yes.....ii) No.....

(b) If yes, what are they?

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……………………………………………………………………………………………
…………....

(c) What are the main challenges facing the sustainable utilization and conservation of Sandalwood conservation and management practices in Kitui County?

……………………………………………………………………………………………
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(d) What do you think should be done in order to solve problems / challenges listed in (c) above?

……………………………………………………………………………………………
……………………………………………………………………………………………

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.....

C: SANDALWOOD SOCIO – ECONOMIC ISSUES

C1. (a) What are the Sandalwood uses?

Part of the plant Use(s)

Root

Stem

Leaves

Others (specify)

(b) What are the active ingredients in the Sandalwood product that makes plant a high value plant?

……

……

……

……

……

……

(c) How does the local community benefit from the sandalwood utilization in Kitui County?

.....

.....

.....

.....

.....

(d) How is Sandalwood final product measured?

i) litres…….ii) kilograms……

(e) What is the market price for Sandalwood product?

Unit of measure Price (Kshs) Remarks

(f) Is there any value addition done to the Sandalwood products?

i) Yes……ii) No……..

If yes what value addition?

D.EXISTING LEGAL AND INSTITUTIONAL FRAMEWORK

D1. Which existing legislations govern utilization of Sandalwood in Kenya?

……

……

……

…….

D2. Do you think legislations stated in D1 above are sufficient to effectively manage and conserve Sandalwood utilization in Kitui? i) Yes……ii) No…....

D3. If no what are the gaps?.....
.....

E. ADDITIONAL INFROMATION

Kindly provide any additional information you think will add value towards sustainable utilization, conservation and management of Sandalwood in Kitui County.……
……
……
……Thank you for your kind co-operation and collaboration with us!

Appendix III: Lead questions for Focused Group Discussions (FGD) on High Value and Multi – Purpose Trees and Shrubs (HVMTS) Study in Kitui County

(1) Can somebody give a brief overview of this locality that is administrative description of the area?

(2) What are the High Value and Multi – Purpose Trees and Shrubs (HVMTS)?

(3) Can you list / mention these HVMTS?

(4) What have they been used for? Moderator to guide the discussion in order to come up with plants for medicinal, timber, food, industrial products amongst other uses.

(5) Which HVMTS have medicinal properties? Name the plant species and diseases known to treat?

(6) Are you aware of Sandalwood plant?

(7) Where is Sandalwood known to grow in your locality?

(8) What are the major uses of Sandalwood?

(9) In the past how was sandalwood plant conserved?

(10) What are the plant species know to grow in association with sandalwood?

(11) When did you start hearing about Sandalwood? Where did you get information from about Sandalwood?

(12) Are there any organizations working towards conservation of Sandalwood in this locality?

(13) How are people involved in harvesting Sandalwood paid? And who pays them?

(14) Where does the Sandalwood harvested taken to and what is it used for?

Thank you for your kind co-operation and collaboration with us!

Appendix IV: GPS Coordinates for sites visited during field data collection in the targeted study areas in Kitui County

GPS COORDINATES FOR SITES VISITED DURING DATA COLLECTION			
NAME OF HOUSEHOLD INTERVIEWED	**LATITUDE**	**LONGITUDE**	**WAY POINTS**
KITUI CENTRAL SUB - COUNTY			
Magret Mueni	388762	9844876	108
Mwinzila Kalovwe	389640	9844011	109
Kanini Mwaniki	388847	9846278	104
Rose Kimwele	389939	9845973	102
Vathei James	389375	9846280	103
Musenye Mathembe	388490	9845730	105
Jackline Kalunda Joshua	391159	9844264	93
Robert Mumo Kiema	390653	9844597	94
Luciah David	388319	9842693	100
Jacinta Muthengi	390898	9844211	91
Doroth Mutua	390235	9844859	95
Mary Mwende	388587	9843998	101
Masila Mutambuki	389715	9845081	96
Kanini Mumo	389236	9844455	97
John Muthembwa Kitonyo	388478	9843054	98
Mwikali Nguli			64
Lawrence Nzuki Kiatine	385590	9843643	60
Esther Kithome	385243	9843308	61
Reginah Katuki Mbiti	386027	9843280	62
Patrick Kimanzi	384660	9843444	63
Lumumba Mutua	385968	9843462	65
Peter Mutunga	386482	9844438	55
Simeon Musembi	386702	9844393	54
Venesi Wambua			53

GPS COORDINATES FOR SITES VISITED DURING DATA COLLECTION			
NAME OF HOUSEHOLD INTERVIEWED	**LATITUDE**	**LONGITUDE**	**WAY POINTS**
KITUI CENTRAL SUB - COUNTY			
Josephine Mwanzia	386924	9844126	52
Mpnah Nyamai	387387	9844541	51
Lucy Kinyamasya	386539	9843999	58
Boniface Mutunga	386716	9843818	59
Munanie Syulu	386703	9844392	57
Mary Ndeka	386321	9844054	56
KITUI SOUTH SUB - COUNTY			
Christine Mulii	407612	9789428	72
Agnes Mbula Kalusu	410735	9790990	71
Philip Musau Mweki	408478	9790990	57
Jane Kasina	409293	9788617	62
Elizabeth Kyeva	410252	9789057	64
Munyau Mutua	408644	9789057	63
Robert Mulatya Muthusi	409502	9789104	63
Mbithe Mbuvu	407967	9789908	69
Nzoki Savi	406934	9790676	74
Beatrice Mukai	406814	9791542	75
Stella Musyoka Mutinda	408277	9789331	60
Mwanzia Makau	410294	9789874	65
Joseph M. Nyamai	409642	9790810	72
William Nyamai	408367	9792267	67
Muthini Miwa	406504	9788631	73
Peter Kiatu	415987	9805590	35
Kawmu Kimeu	415344	9802992	32

GPS COORDINATES FOR SITES VISITED DURING DATA COLLECTION			
NAME OF HOUSEHOLD INTERVIEWED	**LATITUDE**	**LONGITUDE**	**WAY POINTS**
KITUI CENTRAL SUB - COUNTY			
Monica Nzinga	415317	9801460	31
Maria Nzuu	415772	9804452	33
Jennifer Mati	416019	9804908	34
Winfred Nduku	415399	9800494	29
Kambua Mulu	415375	9801066	30
Mary Kiema	413180	9795226	29
Mungooti Mamba	415203	9800465	28
Mwanthi Ngui	414540	9794810	25
Winfred Kyalo	413703	9795015	22
Mungithya Robert	413440	9794313	23
Muthini Kitui	413817	9794734	26
John C.W Mbuvi	413873	9795099	24
Ruth Kisemei	414716	9799814	36
KITUI WEST SUB - COUNTY			
Benedict Musyimi Mitau	391412	9865379	46
Musyoki Nguthu	391899	9865423	44
Kavesa Munyasya	391729	9865448	45
David Maasai	391429	9865580	48
Wambua Nzono	391429	9865580	49
Janet Mwende	391428	9865577	47
Mwende Mwangangi	390803	9865480	50
John Mwinzi Mwendwa	388004	9866854	38
Nicholas Muthengi	387496	9866987	37
Nzambi Nzoka	387191	9867365	36

GPS COORDINATES FOR SITES VISITED DURING DATA COLLECTION			
NAME OF HOUSEHOLD INTERVIEWED	**LATITUDE**	**LONGITUDE**	**WAY POINTS**
KITUI CENTRAL SUB - COUNTY			
Mwende Mutemi	388002	9866853	39
Mukai Mbiti	388604	9866423	40
Mwaki Kyalo	388974	9866101	41
Munyithya Ngundo	389082	9865955	42
Benrodger Nuve Wambo	388975	9866101	43
Josphine Kasuni Nzoka	391323	9870979	87
Titus Mundi Nzale	390591	9870755	90
Kamene Kilonzo	392111	9870427	82
Stephen Musili	391734	9870027	81
Jackson Mutua Mbuvi	391822	9869693	80
Kilelo Mulangi	391612	9868685	77
Damaris Ngusu	392312	9869513	79
Ngina Musyoka	391894	9869370	78
Peter Loti Kayaki	391479	9868348	76
Mutave Musyimi	391104	9870356	85
Annah Temea Mbuvi	391676	9870378	83
Jane Benjamin	390023	9870645	91
Mbula Muthui	389944	9869875	89
Kaunda Joseph	391144	9871270	88
Caroline Mueni	391160	9870080	86

KITUI EAST SUB – COUNTY

NAME OF RESPONDENT	LATITUDE	LONGITUDE
Mwatha Mwanzui	9852704	450389
Mbuve Mwikali	9852627	448029
Rose Ndinda	9853096	4500048
Mumo Nguli	9840737	444949
John Kinyamasyo	9857389	445153
Musembi Kitheka	9848378	447449
Mutua Kitheka	9839849	444759
Mbete Mwele	9847199	446838
Valai Mulatya	9848231	445982
Festus Musyoka Kindili	9848718	447108
Denis Muema Musela	9849973	447611
Alex Muinde	9841813	445299
Makasa Kitheka	9853208	449858
Mutua Mutisya	9856790	445060
Ng'ondu Munyao	9848918	448378
Sophia Nzuka	9850358	446400
Mwisiwa Kasung'e	9840644	445066
Faith Mbuli Daniel	9849661	449062
Kaviti Mwalya	9848181	448154
Peter Muthui	9853397	449137
Makau Mulwa	9859096	443933
Samuel Kimanzi	9855282	446265
George Munyalo	9856836	445274
Julius Kilonzo Ndika	9849995	447725
Mwalya Musyoka	9859996	447721
Joel Kalithi	9859642	447526
Kitonga Ngusi	9853368	449217

NAME OF RESPONDENT	LATITUDE	LONGITUDE
Mumbi Mwanza	9848223	447463
Mwikali Mutula	9848321	447453
Elijah Mutie	9857845	440850
Jeremiah Kiteme	9850341	463268
Nduku Kilungya	9850388	459711
Monze Kikonde	9849832	461499
Musangi Mwambi	9859603	437320
Wambua Ndano	9850504	459355
Nzanzai Mulavi	9860152	440550
Tabitha Kinako	9862064	440864
Kalunda Mutuvya	984848	459520
Kamene Nzukini	9860677	440712
Msikari Kombo	9859341	438367
Josphat Muthungu	9856010	442023
Kinyalili Muli	9859748	438315
Patrick Mbondo Muthami	9858975	439653
Kavalau Anazuki	9858103	440635
Mbuvi Kiteme	9850726	462638
Muli Mauta	9859330	440333
Nzinga Muthami	9860057	439657
John Mulyungi	9860055	439673
Kasauni Mbindyo	9850227	460843
Mulekye Mauta	9859648	440431
Monica Nzomo	9857022	442373
Moiko Mutua	9847407	454266
Kalunde Mwanzia	984598	459225
Juma Musango	97922857	410816
Kai Muthau	9851145	457301

NAME OF RESPONDENT	LATITUDE	LONGITUDE
Naumi Kisilu	9842844	424031
Faith Syong'ombe	9849502	458191
Mary Kivusyu	9850301	463838
Kathina Kavisa	9849337	459866

Appendix V: Correlation Analysis on the Independent and the Dependent Variables

		Distribution	Usage Knowledge	Socio - economic benefits	Environmental impact	Harvesting of *O. lanceolata*
Distribution	Pearson Correlation	1	.542**	.421**	.841**	.666**
	Sig. (2-tailed)		.000	.000	.000	.000
	N		120	120	120	120
Usage knowledge	Pearson Correlation		1	.087	.264**	.744**
	Sig. (2-tailed)			.346	.004	.000
	N			120	120	120
Socio - economic benefit	Pearson Correlation			1	.394**	.781**
	Sig. (2-tailed)				.000	.000
	N				120	120
Environmental impact	Pearson Correlation				1	.580**
	Sig. (2-tailed)					.000
	N					120
Harvesting of *O. lanceolata*	Pearson Correlation					1
	Sig. (2-tailed)					
	N					120

Appendix VI: Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.894[a]	.798	.788	.28306

- Predictors: (Constant), distribution of *O. lanceolata*, usage knowledge of *O. lanceolata*, socio - economic benefit of *O. lanceolata* and environments impact of *O. lanceolata*.

Appendix VII: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	35.871	6	5.979	74.619	.000[b]
	Residual	9.054	113	.080		
	Total	44.925	119			

a. Dependent Variable: Harvesting of *O. lanceolata*

b. Predictors: (Constant), distribution of *O. lanceolata*, usage knowledge of *O. lanceolata*, socio - economic benefit of *O. lanceolata* and environments impact of *O. lanceolata*.

Appendix VIII: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.040	.129		8.085	.000
	Distribution (x_1)	.207	.055	.520	3.743	.000
	Usage knowledge (x_2)	.431	.151	.353	2.862	.000
	Socio - economic benefit (x_3)	.641	.080	.210	1.769	.000
	Environmental impact (x_4)	-.129	.065	-.206	-1.983	.000

a. Dependent Variable: Harvesting of *O. lanceolata*

Appendix IX: Plates

Plate 1: *O. lanceolata* plant growing naturally in the wild at Wikililye in Kitui Central Sub - County

Plate 2: *O. lanceolata* growing areas at Endau hills in Kitui County

Plate 3: Key informant and investigator in the field at Muthale

Plate 4: Confiscated bags of illegally harvested *O. lanceolata* roots and stems at Kitui Police station