The cultural beliefs, values and utilization of East Africa Sandalwood *Osyris lanceolata* Hochst. & Steud. (1832) in and around Chyulu Hills Ecosystem, Kenya

Jane Gachambi Mwangi, Jesse Theuri Njoka, and Harry Spaling

**Correspondence**

Jane Gachambi Mwangi¹, Jesse Theuri Njoka² and Harry Spaling³

¹University of Nairobi, Department of Land Resource Management and Agricultural Technology, Nairobi, Kenya
²King’s University, Environmental studies and Geography, Edmonton, Canada
³Corresponding Author: mwangijane35@yahoo.com

Ethnobotany Research & Applications 22:12 (2021)

**Research**

**Abstract**

*Background:* In Kenya, the endangered East African Sandalwood, sourced mostly from limited natural stands, is widely used by local rural populations for multiple purposes including for nutraceutical and health benefits, but its potential for domestication and poverty alleviation are largely unknown. The purpose of this study was to identify current sources and uses of the plant, cultural values, taboos, and beliefs associated with its use and management, and how local knowledge of the plant is acquired and transmitted to younger generations, all with a view of contributing to its conservation and sustainable use.

*Methods* The data on demographic and socioeconomic characteristics, local knowledge of plant utilization, cultural beliefs, values, and taboos associated with the plant, and transmission of inter-generational knowledge were collected from May 2018 to November 2018. Data were collected from seven traditional healers and 384 household heads with knowledge of the plant, residing in sixty Kamba villages and thirty Maasai villages on the Eastern and Western sides of Chyulu Hills Ecosystem, respectively, using structured questionnaires, semi-structured interviews, and Focus Group Discussions.

*Results:* Findings revealed that the plant was mainly sourced from the natural protected forests. The major uses were medicinal while knowledge on cultural values, taboos and beliefs related to East African Sandalwood were known by only 35% of participants. Plant knowledge was transmitted inter-generationally mainly by parents and grandparents (74%). Differences between ethnic group (*p*=0.000, *X²*=176.173), occupation (*p*=0.000, *X²*=122.615) and on-farm sources of income (*p*=0.000, *X²*=131.568) as well as ethnic group (*p*=0.000, *X²*=138.433), occupation (*p*=0.000, *X²*=113.999) and on-farm sources of income (*p*=0.008, *X²*=64.668) were statistically significant on current uses and the cultural values, taboos, and beliefs of the plant respectively.

*Conclusions:* The results should contribute to the on-going domestication, propagation, and sustainable conservation of the plant. Although the species is used for multiple purposes, its main value was found in medical applications and hence has a commercial potential in the alternative pharmaceutical sector.
Keywords: East African Sandalwood, Chyulu Hills Ecosystem, Traditional knowledge, Cultural values, Cultural taboos, Cultural beliefs

Background

The endangered native species of East African Sandalwood (*Osyris lanceolata* Hochst. & Steud.) has many traditional livelihood, medicinal and cultural uses among several ethnic communities in rural Kenya, but interest in its commercialization for nutraceuticals and essential oils is increasing. This paper examines local knowledge on the use and management of East African Sandalwood with a view to assessing its potential for domestication for rural poverty alleviation and sustainable conservation.

As a member of the family Santalaceae the plant is an evergreen, highly branched shrub or small tree that is quite variable in height ranging from 1.5-9 m (Orwa et al. 2009, Polhill 2005, Wilson 2018). All parts are glabrous (Polhill, 2005). Flowers are small and unisexual with male flowers in axillary cymes and female solitary (Orwa et al. 2009). Leaves are alternate, elliptic or elliptic-oblong, rarely obovate, varying in size from 1.5-6.5 x 0.7-4.0 cm (Polhill, 2005). Great variation in leaf size and shape has elicited a considerable synonymy in this species (CITES 2013) and has led to 15 synonyms as listed on The Plant List (2016). Similar scientific synonyms for the species include *O. abyssinica* Hochst, *O. arborea*, *O. arborea var. rotundifolia*, *O. arborea var. stipitata*, *O. densifolia*, *O. laeta*, *O. oblaneoelata*, *O. parvifolia*, *O. quadripartite*, *O. rigidissima*, *O. tenuifolia*, *O. urundiensis* De Wild., *O. wightiana* Wall. ex Wight (also known as Nepalese sandalwood), *O. wightiana var. rotundifolia* P.C. Tam, and *O. wightiana var. stipitata* (Lecomte) P.C. Tam (Global Plants 2016, The Plant List 2016). In Kenya, East African Sandalwood occurs frequently in semi-arid to arid ecosystems, primarily on stony and rocky soils along an altitudinal range of 900-2175 m. a.s.l (metres above sea level) (Kokwaro 2009). The plant has broad and narrow-leaved varieties that can be found in natural stands in protected areas such as Chyulu Hills, Oldonyo Sabuk National Park and East Pokot trustlands (Mukonyi, et al. 2012). However, in agro-pastoral and other land uses there are signs of intense harvesting of the plant such as in Kajiado-Loitokitok area and Makueni-Chyulu areas (Mukonyi, et al. 2012).

The plant is hemi parasitic (Texeira Da Silva et al. 2016) and requires a host. The major preferred initial or intermediate hosts are *Rhus natatalensis*, *Dodonaea viscosa*, *Tecomaria capensis*, *Catha edulis*, *Apodytes dimidiata* Meyer, *Brachystegia spiciformis*, *Maytenus acuminatus* and *Aphloia theiformis* (Mwang’ingo et al. 2005). Seed or root suckers are the natural mode of propagation. *Osyris lanceolata* Hochst. & Steud. is used for multiple purposes. It is used in ethno medicinal applications as traditional medicine in different parts of the world such as South Africa, Zimbabwe, Kenya, Ethiopia, and parts of Asia e.g Nepal (Erasmus et al. 2015, Estetu et al. 2015, Hilonga et al. 2019, Kefalew et al. 2015, Lourens et al. 2015, Muthee et al. 2011, Njoroge & Bussmann 2006, Nyahangare et al. 2015, Subba et al. 2016).

In Kenya, it is culturally used for medicinal purposes such as an antimalarial (Njoroge & Bussmann 2006), antibacterial and antifungal (Ooko 2009) to treat diarrhea, chest problems and joint pains (William 2010) as well as ringworm, impotence and fatigue (Muthee et al. 2011). Texeira Da Silva et al. (2016) after Girma et al. (2015) reported that methanol extracted from leaves inhibited the growth of pathogens such as *P. aeruginosa*, *P. mirabilis*, *S. typhi* and *S. paratyphi*. The tree is also a source of firewood and timber, especially for carvings, grain mortars, pestles, pegs, and for building poles and bedsteads. It is traditionally used to preserve milk in gourds for long periods and the bark produce dyes to brew herbal tea (William, 2010). The bark is also used for leather tanning and provides a strong dyestuff. Root fibers are used in basketry. The scented roots and wood provide essential oils which are used to make cosmetics and perfumes (Orwa et al. 2009). Many households utilize *O. lanceolata* Hochst. & Steud. for their subsistent livelihoods and as a medicinal source for human and ethno veterinary purposes (Moichwanetse 2020).

The heartwood of East African Sandalwood contains essential oil that is traded internationally in the perfumery industry (Bunei 2017, Ochanda 2011) as well as herbal medicine which is traded locally (Hilonga et al. 2018, Kariuki et al. 2018, Omara 2020). This may provide an opportunity for its domestication and commercialization in Kenya, particularly it was used as a substitute for essential oil as natural populations elsewhere such as *Santalum* and the *Pterocarpus* species had either been banned from export or had diminishing natural populations (Groves & Rutherford 2016, Hilonga et al. 2019). Its further development in Kenya should enhance livelihood benefits and help alleviate poverty among rural pastoral and agro-pastoral households (Mutisya et al. 2019). On the other hand, over-harvesting of this endangered plant among natural populations, as has occurred in Kajiado-Loitokitok and Makueni-Chyulu areas (Mukonyi et al. 2012) and exploitive practices such as uprooting an entire tree for its essential
oil, as well as illegal wood trade of a protected species are sustainability challenges to be overcome (Bunei 2017, Kariuki et al. 2018)

Though *O. lanceolata* Hochst. & Steud. is a threatened species, protected under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2013, Wilson 2018), of which Kenya is a signatory, research on its sustainable utilization and management is lacking in Kenya (Mukonyi et al. 2012). In particular indigenous knowledge systems on the use and management of East African Sandalwood have not been systematically studied among diverse cultural communities residing in ecological zones conducive to this species. A concern that indigenous knowledge about Sandalwood may be disappearing, just as its commercialization is intensifying, adds urgency to such research. The purpose of this study is to describe local knowledge about the use of East African Sandalwood with a view to enhancing its sustainable conservation. It aims to identify knowledge on current and traditional utilization, indigenous beliefs, values and taboos of the plant, and intergenerational transmission of this knowledge. It also assesses how the current and traditional use is influenced by demographic (gender, age) and socioeconomic (ethnicity, education, occupation, sources of income, religion) attributes, and time of stay in the area.

The field research adopted a case study approach focused on the Chyulu Hills Ecosystem, a UNESCO World Heritage Site (UNESCO & WHC 2010), that is straddled on the Western and Eastern sides by the Maasai and Kamba ethnic groups, respectively. The traditional knowledge, use and management of East African Sandalwood are ascertained for each group. Findings from this case should contribute to the on-going sustainable domestication, commercialization, and conservation of this species in Kenya.

Materials and Methods

Study Area

The Chyulu Hills Ecosystem is located in the expansive (2000 Km2) Amboseli-Tsavo Ecosystem 190 Km South-East of Nairobi (GoK 2013). The hills cover an estimated 775.8 Km2 with a population density of 0.11 Km2 (Kanui et al. 2016). They comprise mainly the Chyulu Hills National Park, Tsavo West National Park, Kibwezi Forest Reserve and also the West Chyulu Game conservation area. Administratively, the study area is in Kibwezi and Makindu Sub-counties of Makueni County and Loitokitok Sub- County of Kajiado County, located on the Eastern and Western sides of the Chyulu Hills Ecosystem, respectively (Figure 1).

The area is characterized by temperature ranges from 20 to 30°C and bimodal rainfall with average annual precipitation varying between 350-500 mm/yr in the lowland rangelands and slightly more than 1000 mm/yr in the Chyulu Hills, which supports a montane forest (Kiringe et al. 2015, Reid et al. 2004). The regional slope has a gradient of 30-60%. Altitude varies from less than 900m above sea level to a maximum of 2175 m above sea level. Climatically, the ecosystem is arid and semi-arid, and in agro-climatic zone IV with low potential for crop production (Muriuki et al. 2011, Sombroek et al. 1982).

In recognition of its distinct volcanic landforms, unique biodiversity and conservation importance, the Chyulu Hills Ecosystem was nominated in 2010 by the Kenya Wildlife Service as a UNESCO World Heritage Site (UNESCO & WHC 2010). Distinctive habitats include hilltop forests, woodlands, groundwater forests, wooded lava outcrops, grasslands, and caves (Kiringe et al. 2016). *O. lanceolata* Hochst. & Steud. is distributed in this ecosystem and, although protected under CITES, was heavily smuggled and exploited in the hills between the years 2000 and 2005 (CITES 2013).

The Maasai and Kamba ethnic groups dominate the study area. Kamba villages are found at the Eastern side of the Chyulu Hills at elevations below 1100 m, which are dominated by *Acacia-Commiphora* bushland. The Kamba’s are primarily agro-pastoralists, growing a variety of drought resistant grains and pulses like pigeon peas, maize, sorghum, millet, and beans, as well as livestock for milk and meat (GoK 2010). They value woody plant resources for herbal medicine, charcoal, and wood-carving activities (GoK 2013a).

Maasai villages predominate the Western side of the Chyulu Hills at elevations generally below 1300 m where there is dry grassland, mixed with *Acacia drepanolobium* (KWS 2008). The Maasai are traditionally pastoralists who own and manage Mbirikani and Kuku group ranches for pastoralism and ecotourism activities. Farming is also done in wetland areas where there is more reliable rainfall (GoK 2013b). The Maasai value woody plant resources for livestock fodder and medicinal purposes (Kimondo et al. 2015).
Data Sampling and Collection

People bordering Protected Areas (PAs) are usually very knowledgeable regarding threatened plants for which PAs remain the main refuges (Balima et al. 2018). Households in the study area were surveyed to ascertain this knowledge for East African Sandalwood among several locals. Initially, chiefs and communities were consulted to clarify the objectives of the study and identify potential participants who had knowledge of East African Sandalwood.

Data collection tools included structured questionnaires, semi-structured interviews, and Focus Group Discussions (Creswell 2014). These tools have been used to collect ethno-botanical data by different authors (Arévalo-Marin et al. 2015, Rajbanshi & Thapa 2019, Teka et al. 2020). Alexiades (1996) has also recommended their suitability for conducting ethnobotanical research for wild plants. These tools were designed to answer six research questions: (1) What is the local name of East African Sandalwood and its meaning? (2) What beliefs, values, or taboos are associated with the use and management of Sandalwood in your community? (3) What is East African Sandalwood used for? (4) How is knowledge about this plant and its use and management conveyed to others? (5) Who transmits this knowledge to others? (6) What socio-economic factors influence cultural beliefs and utilization of sandalwood?

Multistage sampling was used to obtain a representative sample from each of the following locations selected for their proximity to the Chyulu Hills Ecosystem: Makindu, Kikumbulyu, Nthongoni, Utithi, Tsavo West National Park, Chyulu Game Reserve, Kenyewa, Merrueshi and Kiboko (Figure 1). Simple random sampling was used to select households in villages within and 0-5 Km from the Chyulu Hills Ecosystem.

Figure 1. Map of the Chyulu Hills Ecosystem showing the locations sampled among the Kamba and Maasai communities in Kajiado and Makueni Counties.
The structured questionnaire was pretested among 45 randomly selected participants using the split-half technique and a reliability coefficient of at least 0.7 (Fraenkel & Wallen 2009). Since a reliability coefficient of 0.72 was obtained from the pretest, the instrument was considered suitable for the survey.

A total of 384 adult participants (232 men, 152 women) were surveyed, all 18 years and above. This sample size was calculated by the formula (Omona 2013):

\[
 n = \frac{Z^2pq}{d^2}
\]

Where \( n \) was the desired sample size, \( Z \) is the standard normal deviate at the required confidence level, \( P \) is the proportion in the target population estimated to have used or knew the species (50%), \( q \) is 1 - \( P \) and is the proportion of individuals not knowing the species = 1 - \( P \) (50%) and \( d \) is the level of the statistical significance. Through the pre-test it was discovered that 50% of the interview participants in all the sub-locations, know and use \( O. lanceolata \). A sample size of 384 persons was determined for a 5% level of statistical significance. More men accepted to sign the consent protocols and participate in the study, probably because they had more knowledge of the plant as they are typically the primary users and sellers of it, (89.6%) as compared to women who are more involved in domestic tasks (Ochanda 2010).

The 384 structured questionnaires focused on the informant’s demographic (gender, age) and socioeconomic (ethnicity, education, occupation, sources of income, religion) characteristics, time of stay in the area, knowledge of utilization of the plant in their local areas, cultural beliefs, values and taboos associated with the plant, and transmission of inter-generational knowledge regarding utilization and management of Sandalwood.

Seventeen semi-structured interviews and two focus group discussions in the Kamba and Maasai communities further explored and verified how plant-based knowledge of the East African Sandalwood is transmitted and how it is associated with cultural beliefs, values, and taboos. Participants (9 Kamba, 8 Maasai) for the semi-structured interviews were selected using a snowball sampling strategy (Creswell 2014) in consultation with the chiefs from each location to identify individuals known for their knowledge of plants. Participants in the two focus group discussions were also selected in consultation with the respective chiefs from each ethnic community, and consisted of 13 Kamba (7 men, 3 women, 3 traditional healers) and 13 Maasai (5 men, 4 women, 4 traditional healers) (Alexiades 1996).

The structured questionnaires, semi-structured interviews and focus group discussions were administered in the Kamba and Maasai languages with the assistance of local translators, and responses transcribed into English.

**Data analysis**

Descriptive statistics such as frequencies, percentages, standard deviations, means and bar charts were used in the analysis and are summarized below. Chi-square was used to determine the association between the socioeconomic factors (education level, age, gender and religion on-farm and off-farm sources of income), time of stay in the area and cultural beliefs, values, taboos and the knowledge systems on utilization and management of the plant. The analysis was performed in SPSS Version 22 (IBM 2013). The data from semi-structured interviews and focus group discussions was analyzed by thematic content analysis.

**Results**

**Major sources of East African Sandalwood**

The major source of Sandalwood reported by the research respondents was the natural protected forests (90%) (Figure 2). However, sources differed by subspecies and location. The narrow leaved is commonly used by Kamba (46%) and Maasai (21%) communities, whereas the broad leaved is used mostly by the Maasai Community (17%). Other sources include my farmland (5%), other people’s farmlands (4%) and home gardens (1%), but only by the Kamba Community. Overall, the narrow leaved sourced from the forests is the main subspecies in use.
Local names and meanings for East African Sandalwood

Local names were elicited from participants in each ethnic group. ‘Ndonga’ is the most common name among the Kamba and ‘Olosesiai’ among the Maasai (Table 1). However, the meanings of local names varied among and within both groups. For example, 42% of Kamba participants reported that ‘Ndonga’ meant a cure for all infections and diseases but only 3% of the Maasai described the same meaning for ‘Olosesiai’. Some (8%) Kamba respondents reported that ‘Ndonga’ meant richness and had been derived from the name ‘Kitonga’, a rich person. Other reported meanings included poison, neutralizer of poison or coloring in basketry. In contrast, 11% of Kamba and 36% of Maasai respectively claimed that ‘Ndonga’ and ‘Olosesiai’ local names did not have any local meaning.

Table 1. Local names and their meanings for East African Sandalwood

| Local Name (n=384) | Cure/Medicinal | Richness | No local meaning | Total |
|-------------------|----------------|----------|------------------|-------|
| Ndonga (Kamba)    | 42             | 8        | 11               | 61    |
| Olosesiai (Maasai)| 3              | 0        | 36               | 39    |
| Total             | 45             | 8        | 47               | 100   |

Utilization of East African Sandalwood

East African Sandalwood was mainly used for medicinal purposes (64%) by both communities (Table 2). This constituted 48% for the Kamba tribe and 16% for Maasai tribe. Local examples included a powder made from plant parts was applied on snake bites and scorpion and centipede stings to neutralize poison. A paste made from plant parts mixed with water was used to heal ring worm and skin rashes, applied on open wounds to clot blood, and dry and heal them, as a pain killer for circumcision and toothache, and for ethnoveterinary purposes (goats, chicken,
and cows). A paste made from plant parts mixed with milk was used for nutraceutical purposes in children and generally as a curative and preventive drug against diarrhea in children.

Table 2. Knowledge on the utilization of East African Sandalwood amongst respondents.

| Category of uses (n=376)                                      | Frequency (%) |
|--------------------------------------------------------------|---------------|
|                                                              | Maasai Community | Kamba Community | Total |
| Medicinal purposes                                           | 48            | 16              | 64    |
| Tonic in soups                                               | 1             | 0               | 1     |
| Medicinal purposes, tea from roots and tonic in soups         | 0             | 21              | 21    |
| Medicinal purposes and firewood                              | 11            | 0               | 11    |
| Medicinal purposes and tonic in soups                         | 0             | 0               | 1     |
| Medicinal purposes and building                               | 1             | 0               | 1     |
| Medicinal purposes and sell it to other traders for export    | 1             | 0               | 1     |

A difference in use among the two groups is that Kamba respondents (21%) reported using the plant to brew tea from roots and make tonic in soups, in addition to medicinal purposes (Table 2). Only 1% of the Maasai Community uses the plant as a tonic in soup. On the other hand, only the Maasai Community (11%) claimed using the plant for both medicinal purposes and firewood. Use for building material (1%) and selling of plant parts to traders for export (1%) is minor.

Cultural beliefs, values and taboos associated with use and management of East African Sandalwood in Kenya

This study identified several beliefs, values and taboos associated with the use and management of *O. lanceolate* Hochst. & Steud. although 65% of the interview participants mentioned that they were not aware of them (Table 3). Of those that were, 13% (Kamba 5%, Maasai 8%) identified the main cultural value of the plant as medicine. For example, the sandalwood leaves are boiled and given to women during their monthly periods to control pain and is also believed to stop bleeding in women. However, a contrary belief claimed by a few Kamba (4%) and Maasai (1%) respondents is that the plant is believed to cause barrenness in women, and miscarriages and abortion if touched or used by pregnant women.

Table 3. Beliefs, values, and taboos associated with use and management of East African Sandalwood in Kenya

| Cultural beliefs (n=384)                                      | Frequency (%) |
|--------------------------------------------------------------|---------------|
|                                                              | Kamba Community | Maasai Community | Total |
| Believed and known to cause miscarriage to pregnant mothers and barrenness in women and ladies | 4             | 1               | 5     |
| Believed that owning sandalwood in your area/forest/land implies richness | 1             | 0               | 1     |
| Children not allowed to use it, go where it is planted or hold it as it is preserved for adults | 1             | 0               | 1     |
| Believed that once its branch is lit it helps to stop and chase away snakes | 7             | 0               | 7     |
| Believed and used as medicine for all human and animal diseases and especially children. | 5             | 8               | 13    |
| Associated with marriage and circumcision cultural events and rituals | 6             | 0               | 6     |
| Associated with witchcraft/wizards especially those who made medicine from it | 1             | 0               | 1     |
| Believed in making rain if plant material was smeared on a goat being slaughtered | 1             | 0               | 1     |
| Don’t know                                                  | 35            | 30              | 65    |

Several cultural beliefs, values and taboos were reported only among the Kamba respondents (Table 3). For instance, it was reported during their Focus Group Discussions that dried plant powder was believed to remove...
In addition, they believed that if the branch of the plant was lit, it could be used to chase away snakes (7%). They also associated the plant with marriage and circumcision events and rituals (6%). For example, it was a sign of pride to circumcised boys who had applied the plant powder, and it was traditionally used as a bind between husbands and wives who divorced frequently and re-married again. The plant also produced a pleasant aroma in shrines when offering sacrifices. It was also believed that owning Sandalwood in your area/forest/land implied richness (1%). In addition, it was believed that it would rain if plant powder was smeared on a goat being slaughtered (1%). Moreover, the children were not allowed to harvest it or touch it as the plant is only to be used by adults (1%).

**Transfer method for knowledge on use and management of East African Sandalwood**

The most common way of transferring knowledge on the use and management of East African Sandalwood is by word of mouth (Kamba 58%, Maasai 38%) (Table 4). The other ways of transmitting knowledge were training through seminars (1%), school (1%), farmer field school (1%), self-taught (1%) but only reported by Kamba respondents.

**Table 4. Transfer method for knowledge on use and management by Kamba and Maasai community**

| Transfer Method (n=369)              | Frequency (%) |
|--------------------------------------|---------------|
| Oral knowledge passed down           |               |
| Kamba Community                      | 58            |
| Maasai Community                     | 38            |
| Total                                | 96            |
| Training Seminar                     | 1             |
| Kamba Community                      | 1             |
| Maasai Community                     | 0             |
| Total                                | 1             |
| School                               | 1             |
| Kamba Community                      | 1             |
| Maasai Community                     | 0             |
| Total                                | 1             |
| Farmer field school                  | 1             |
| Kamba Community                      | 1             |
| Maasai Community                     | 0             |
| Total                                | 1             |
| Self-taught                          | 1             |
| Kamba Community                      | 1             |
| Maasai Community                     | 0             |
| Total                                | 1             |
| Total                                | 100           |

**Medium used to obtain knowledge on use and management of East African Sandalwood**

Knowledge on use and management of East African Sandalwood was mainly acquired from parents and grandparents (74%), followed by farmers (15%), friends and businesspeople (8%), as well as sellers and buyers (1%) (Table 5). For example, the children were taught by their mother when they were being given the plant for medication, so that they didn’t misidentify it. Also, those who used the plant taught each other to distinguish it from other plants.

**Table 5. Medium used to obtain knowledge on use and management of East African Sandalwood.**

| Person who transferred                        | Frequency (%) |
|-----------------------------------------------|---------------|
| Tawseef Ahmad Mir’, Rakesh Kumar Khare and Muatasim Jan (n = 369) |               |
| Kamba Community                               | Maasai Community | Total    |
| Grand father                                 | 16             | 3     | 19     |
| Grand mother                                 | 13             | 2     | 15     |
| Father                                       | 3              | 10    | 13     |
| Mother                                       | 3              | 7     | 10     |
| Read from books                              | 1              | 0     | 1      |
| Farmers                                      | 15             | 0     | 15     |
| School teachers                              | 1              | 0     | 1      |
| Father and Mother                            | 0              | 4     | 4      |
| Grandfather and grand mother                 | 1              | 2     | 3      |
| Grandfather/grand mother and father/mother   | 0              | 10    | 10     |
| Friends and businesspeople                   | 8              | 0     | 8      |
| Sellers and buyers                           | 1              | 0     | 1      |

**Demographic and socioeconomic factors affecting knowledge of East African Sandalwood**

The ethnic group (p=0.000, $X^2=176.173$), level of education (p=0.011, $X^2=42.712$), occupation (p=0.000, $X^2=122.615$) and on-farm sources of income (p=0.000, $X^2=131.568$) were significant and positively associated with
the ethno botanical knowledge of current utilization of the plant (Table 6). Other factors like gender, religion, off-farm sources of income, years of stay in community and age were insignificant in this study.

Table 6. Socio-economic factors influencing knowledge on use of East African Sandalwood

| Cultural values on use and management of East African Sandalwood | Uses of East African Sandalwood |
|---------------------------------------------------------------|---------------------------------|
| $\chi^2$ Value | Sign. (2-sided) | $\chi^2$ Value | Sign. (2-sided) |
|----------------|----------------|----------------|----------------|
| Ethnic tribe | 138.433 | 0.000* | 176.173 | 0.000* |
| Sex | 7.175 | 0.518 | 9.632 | 0.141 |
| Education level | 66.699 | 0.000* | 42.712 | 0.011* |
| Occupation | 113.999 | 0.001* | 122.615 | 0.000* |
| Religion | 2.351 | 0.968 | 1.723 | 0.466 |
| Off-farm sources of income | 40.452 | 0.772 | 29.907 | 0.470 |
| On-farm sources of income | 64.668 | 0.008* | 131.568 | 0.000* |
| Years of stay in community | 115.579 | 0.000* | 51.101 | 0.353 |
| Age | 89.461 | 0.003* | 41.517 | 0.492 |

Knowledge on cultural beliefs, values and taboos associated with use and management of the plant varied significantly and was positively associated with the ethnic group ($p=0.000, \chi^2=138.433$), age ($p=0.003, \chi^2=89.461$), years of stay in the village ($p=0.008, \chi^2=115.579$), level of education ($p=0.000, \chi^2=66.699$), occupation ($p=0.000, \chi^2=113.999$) and off-farm sources of income ($p=0.008, \chi^2=64.668$) (Table 6).

Discussion

Local names and meanings for East African Sandalwood

The local names ‘Ndonga’ as elicited by Kamba and ‘Olosesiai’ by Maasai participants agreed with the names documented for East African Sandalwood by different studies (Muthee et al. 2011, Orwa et al. 2009). However, the meanings of these names have not been reported in any other study. Further, similarities in the meanings between the two ethnic groups may be elucidated by the common medicinal usages associated with the plant. The slight similarities on meanings of local names (curative/medicinal) of East African Sandalwood between Kamba and Maasai community may be an indication of common indigenous knowledge of the curative properties of *O. lanceolata* Hochst. & Steud.

Categories of uses of East African Sandalwood

This study’s findings of the local use of East African Sandalwood for various medicinal purposes (64%) are congruent with those of many other studies. In Kenya, it was used to cure diarrhea (Orwa et al. 2009) as well as treat human and livestock diseases among the Kamba in Chyulu Hills, Kibwezi Sub-county (Ochanda 2011). In Loitokitok Sub-County, it was used by the Maasai Community to treat ringworm, impotence, and fatigue (Muthee et al. 2011).

In Tanzania, it was used to cure anemia and Sexually Transmitted Diseases (STDs) and its plant extracts cures Hepatitis B (Orwa et al. 2009). In the Southern Highlands it treated STDs, anemia, backbone and stomach pains, fungus and typhoid (Mbunde et al. 2017).

In South Africa, it was used to manage candidiasis and related infections in the Venda region (Masevhe et al. 2015) and treat Erectile dysfunction in Capricorn District Lepelle-Nkupi Municipality in Limpopo Province (Erasmus et al. 2015). In different parts of Ethiopia, a similar plant *Osyris quadriflora* Salzm. ex. Decne was traditionally extracted in its leaves by the local people to treat malaria (Girma et al. 2015).

In the medicinal use of this plant was scientifically validated for its pharmacological activities by various studies carried out in the world. For example, the bioactive secondary metabolites noted in the root, stem and stem bark of *O. lanceolata* Hochst. & Steud. In Kenya were active against *Staphylococcus aureus* (Ooko 2009). Those noted in the leaves of a similar plant, *Osyris wightiana* Wall in Nepal were highly active against *Escherichia coli*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Salmonella typhi* and *Candida albicans*. They had both antibacterial and antifungal activities (Paudel & Gyawali 2014). Similarly, Bhandari et al. (2017) revealed that, the
antibacterial property of methanolic extract of leaves of *O. lanceolata* Hochst. & Steud. from the Western region (Rupandehi and Palpa districts) of Nepal may have been due to dihydro-bagarofuran polyesters chemicals that were also isolated by Yeboan and Majinda (2013) from the root bark and stem bark of the same plant harvested in Botswana. The polar organic compound also showed antibacterial activity against *S. aureus* and *E. coli*. It also displays multiple pharmacological activities due to their unique framework that can provide ligands to interact with multiple receptors. They have been described to have acetyl cholinesterase (AChE) inhibition activities, insecticidal, anti-HIV, anti-cancer and multidrug resistance (MDR) reversal in literature (Yeboan & Majinda 2013). However, their pharmacological activities have not been fully scientifically validated in Kenya.

Although both the Kamba and Maasai reported use of *O. lanceolata* Hochst. & Steud. for numerous medicinal purposes only the Maasai respondents (21%) use the plant to brew tea from roots and make tonic in soups, in addition to medicinal purposes. Similarly, the dried leaves of *Osyris wightiana* Wall are used in Central Nepal as a traditional wild herbal substitute for tea (Paudel & Gyawali 2014, Shyaula 2012).

Though the selling of the plant parts to traders was minor, it is surprising because 64% of the respondents previously reported being involved in selling the plant among the Kamba Community in Kitui County (Ochanda 2011) and Kitui County (Mutsiya et al. 2019). This change in use may be attributed to a reduced appearance of the plant in its local distribution or its protected status (CITES 2013).

Nevertheless, extensive local knowledge of East African Sandalwood and its widespread use for medicinal purposes among the Kamba and Maasai people, as well as supporting scientific evidence of the plant’s pharmacological and medicinal properties, point to its potential commercial value although further pharmacological studies are required to ascertain if *O. lanceolate* Hochst. & Steud. in Kenya has similar or other phytochemicals as reported elsewhere. If so, the Kamba and Maasai, and other indigenous groups in Arid and Semi-Arid lands, may be motivated to propagate and domesticate the species for improved livelihoods while concurrently conserving the remaining natural populations.

**Cultural beliefs, values and taboos associated with use and management of East African Sandalwood in Kenya.**

The lack of awareness (65%) of beliefs, values and taboos associated with the use and management of *O. lanceolate* Hochst. & Steud. may be attributable to a change in the inter-generational transmission of local knowledge and cultural values as an older generation gives way to the next, which may exhibit less interest in traditional knowledge and culture due to social changes associated with economic development, technology, and globalization (Geng et al. 2016). Another explanation may be that it is hard to codify the esoteric elements that are embedded in Africa’s indigenous knowledge practices in traditional medicine as it is considered secret for a select few traditional healers who utilize it for their livelihood. This limits transmission of certain types of indigenous knowledge within the same generation and from one generation to another (Masango 2020). Although this study set out to identify traditional beliefs, values and taboos associated with the plant, and is among the first to do so, socio-cultural changes imposed from the outside and secretive indigenous knowledge may impinge on the potential development and commercialization of East African Sandalwood.

According to the Focus Group Discussions, the plant was considered a taboo as it was thought to protect the family against (‘Kalinga’) which was believed to be witchcraft among the Kamba community. This implied that the plant is useful for achieving magic-religious fulfillments in families by protecting them against wizards, enemies, and witchcraft. This taboo protected the unnecessary cutting of the plant, hence prohibited its misuse. The taboos preventing unnecessary cutting of trees have been observed in other studies where particular natural grooves or sites associated with spirituality or sacred spaces had a positive impact on conserving them (Adewoyin et al. 2020, Ssebunya & Okyere-Manu 2017).

Considered a fetish, the plant is believed to fulfill personal desire or aspirations such as richness - owning Sandalwood on one’s land or in one’s community symbolized riches (1%). In addition, the plant was believed to have supernatural powers for rainmaking - it would rain if its powder was smeared on a goat being slaughtered.

Segment taboos were also reported for this plant. Segment taboos occur if a cultural group bans the use of a species for specific time or age, sex, or social status. For example, the Kamba women were prohibited from harvesting *O. lanceolata* Hochst. & Steud. during menstruation and pregnancy as it could cause barrenness and cause miscarriages. In addition, the children were not allowed to harvest it or touch it as the plant is only to be...
used by adults. Segment taboos for women, pregnant women, children, and menstruating females are common (Colding & Folke 2001, Sharma et al. 2021) and encountered for other plant species among African groups such as the Vhavenda and the Bapedi in South Africa (Constant & Tshisikhawe 2018, Ooko 2009, Rasetha et al. 2013).

Though the plant is an actively protected species in Kenya; there is lack of evidence to ascertain that the restrictions like the beliefs, values and taboos reported in this study will ultimately contribute to sustainable use of the plant, in part because these are unknown to 65% of the Kamba and Maasai respondents, and possibly because their traditional practices may be gradually eroding from one generation to the next or considered indigenous secrets. Nevertheless, traditional beliefs, values and taboos may contribute to in-situ conservation of East African Sandalwood among the Kamba and Maasai communities. This is because understanding local cultural values is essential for sustainable use and management of the species (Etongo et al. 2017). The continuation of ritual practices has critical potential for conservation of natural resources. Keeping traditional beliefs and practices alive may contribute to endangered species conservation, including through sustainable harvesting (Kosoe et al. 2020). In the absence of effective public conservation policies, local beliefs, and practices play an important role in both conserving endangered species and their domestication, propagation, and sustained use for poverty alleviation (Sharma et al. 2020).

**Knowledge transmission on use of East African Sandalwood**

Knowledge of Sandalwood was mainly transmitted vertically (from parent to offspring) through mouth and ‘learning by doing’ from everyday interactions with relatives such as helping parents to harvest the plant for medicinal purposes as well as preparing plant materials for use. A similar finding by Amsalu et al. (2018) indicated that indigenous knowledge on medicinal plants was orally passed to the family members. This is supported by Teka et al. (2020) that found that the participants obtained their indigenous knowledge of medicinal plants orally, and 82% of them obtained it from family members. A study by Wanjohi et al., (2020) and Kewessa et al. (2015), likewise indicated that, knowledge of the use of indigenous plant species was obtained orally from parents, grandparents, relatives, and friends.

Knowledge was also acquired through oblique transmission from formal apprenticeships with farmers, friends, businesspeople, and traditional healers among the Kamba community, as well as clan gatherings during the life stage of moranism when they learn the tribal customs, cultural meetings in the bush, storytelling and herding in Maasai Community. This is consistent with some studies on knowledge acquisition of other plants, which reported that learning of plant knowledge took place through hands-on experience and observation that was, in turn, reinforced through apprenticeships with knowledgeable elders and relatives (Constant & Tshisikhawe 2018).

The inter-generational transmission of traditional knowledge is intrinsically linked with continuity in the means of interaction and engagement with plants and the land through the presence of well-informed elders and apprentices. This system of knowledge acquisition may be disrupted if the elders and next generation do not engage with the land and plants in daily life (Murphy et al. 2016). Local leaders and community members should encourage and facilitate the uptake of traditional beliefs, values and cultural taboos/practices and adherence to local regulations that are conducive to the sustainable use and management of East Africa Sandalwood (Constant & Tshisikhawe 2018).

**Influences of socio-economic factors on knowledge of East African Sandalwood**

The significant differences in use by ethnic group implied that these are group-specific and are probably due to preferences of each group and historical use. Each ethnic group has different ethnic affiliations (Salako et al. 2018). This study revealed that the Kamba ethnic groups had more knowledge and more uses of *O. lanceolata* Hochst. & Steud compared to the Maasai Community. Such variations could also be explained by differences in cultural beliefs and values, as highlighted by other ethno-botanical findings (Balima et al. 2018) as well as plant distribution range and abundance (Atakpama et al. 2015; Salako et al. 2018). The dissimilarities could also be due to variations in cultural livelihoods (e.g., farmers vs pastoralists) or different methods of transmission of knowledge from one generation to another. Further investigations are needed to gain additional insight into transmission of knowledge of uses of *O. lanceolata* Hochst. & Steud. between Maasai and Kamba ethnic groups, especially in an African context where traditional knowledge is orally transmitted from one generation to another (Goudégnon et al. 2017).

The significant association of knowledge on use of East African Sandalwood with educational level might have been attributed to more awareness of biodiversity (forests and other natural resources) and sustainability issues like deforestation, CITES etc. This concurred with other studies that indicated that the medicinal plant knowledge
among the respondents significantly differed with the education level (Dapar et al. 2020). However, this study disagreed with the study carried out by Kunwar et al. (2018) which reported that there was higher knowledge of medicinal use for plants among the non-literate participants.

Other sociocultural factors such as occupation and on-farm sources of income also had significant association with knowledge of use of East African Sandalwood. Different studies also reported the influence of occupation on knowledge of plant use (Atreyu et al. 2018, Dapar et al. 2020, Paniagua-Zambrana et al. 2014). Participant age and length of stay were insignificant in this study, as was reported by Goudégon et al. (2017), for Lannea microcarpa plant in the Benin’s Sudanian Savannah. However, many studies for other plants have reported positive association of age with the ethno-medicinal knowledge of plant use (Kunwar et al. 2018, Salako et al. 2018).

The positive significant association of cultural beliefs values and taboos with the ethnic group revealed significant differences between the Kamba and Maasai groups. These variations in ethnicity with cultural uses, values and beliefs corroborate other findings for other plants that showed significant influences of ethnicity on cultural plant uses (Balima et al. 2018).

The significant and positive association between age and years of stay of the informants with the ethnobotanical knowledge of cultural uses, values and beliefs indicated that the elders had more knowledge of the plant than youngsters. The result from the interview schedules and Focus Group Discussions further showed that as the age of the interview participants increased, their level of knowledge on use as well as cultural values and beliefs associated with use of the plant increased (Atapkama 2015). This could have been due to the various uses and the cultural beliefs and values they experienced as their age increased. For instance, Kunwar et al. (2018) reported that longer length of stay in an area helps in accumulating greater amount of knowledge required for wise use of natural resources.

The age-based differences in knowledge of plants could also have been derived from experience and degree of cultural contact with indigenous plants. The lower local or regional abundance of the plant may also have slowed the process of knowledge acquisition, resulting in greater knowledge discrepancies among the age categories, especially between the younger and older informants (Dapar et al. 2020, Salako et al. 2018). However, further studies would be needed to clarify this proposition in *O. lanceolate* Hochst. & Steud. While the acquisition of knowledge depends on time (Albuquerque & Hanazaki 2009), the magnitude of the gap of knowledge among age categories depends on the local or regional abundance of the plant (Salako et al. 2018).

For education level, there was a significant difference between those who were literate and illiterate. Those who had higher levels of education had more knowledge on cultural values and beliefs associated with use and management of East African Sandalwood. This agreed with the study conducted by Zent (1999) which revealed that, the inhabitants of the Southern Amazon who had formal education placed greater value on traditional knowledge and struggled harder to acquire it. However, this study contrasted with that of Constant and Tshisikhawe (2018) which revealed that, modern education systems often eclipse the transmission of traditional forms of knowledge, where the youth perceive the former to be superior to the latter. The introduction of systems of western education led to less time spent on the land, lack of plant-based knowledge and not adhering to moral codes, rituals, and taboos (Constant & Tshisikhawe 2018). Similarly, Umair, Altaf and Abbasi (2017) reported, higher traditional knowledge of plant use among non-literate participants in the Pakistan Himalayas.

**Conclusions and Recommendations**

This study concludes that East African Sandalwood plays a traditional but significant medicinal role among the Kamba and Maasai communities of Makueni and Kajiado Counties, respectively. This important function should be a key component of a sustainable use, management and conservation plan for the species while taking into consideration the ethnic affiliations, education level, occupation, and on-farm sources of income of the targeted group. Enhancing this traditional medicinal role is a reason for its on-going domestication. The multipurpose use of the plant among the Maasai and Kamba communities implies that domestication is likely to be welcomed. Based on the plant’s many and varied preventive and curative claims, some supported by scientific knowledge, *O. lanceolate* Hochst. & Steud. also has significant commercial potential although more research on medicinal and pharmacological properties is needed to support such development.

The commercial role of the plant in Kibwezi District (now part of Makueni County) was previously recognized by Ochanda (2011), before the plant became threatened (CITES 2013). It is now opportune to integrate the plant’s
potential for commercialization and need for propagation, so that both people and the species may benefit. There is a need to raise more awareness for *in-situ* and *ex-situ* conservation among the local communities.

Knowledge on the use and management of East African Sandalwood was mainly acquired orally from parents and grandparents. Keeping this means of transmission intact is critical for the next generation of highly knowledgeable elders as the guardians of indigenous knowledge and sustainable use, management, and conservation of the species for future generations. This study was among the first to identify traditional beliefs, values and taboos associated with the East African Sandalwood among the Kamba and Maasai communities. Time is urgent because only a few respondents still retained this cultural knowledge of the plant for transmission to the next generation. However, this should be done while taking into consideration their level of education, ethnic affiliations, occupation, on-farm sources of income, length of stay and age.

From the study findings, it recommended that further research should address the following issues:

1. Determine the interacting effects of multi-scale abundance, socio-demographic attributes, and the transmission of cultural knowledge on values, rituals and taboos of East African Sandalwood.
2. Determine the detailed role of traditional beliefs, values, and rituals in conserving the East African Sandalwood in all parts of Kenya where it grows.
3. Investigate the ethno-veterinary and human utilization of the plant and transmission of this knowledge in the other parts of Kenya where it grows.
4. Identify adequate activities, laws and policies that would help to stop the illegal smuggling and trafficking of the plant and promote sustainable cultivation of the plant as economic source of income.

**Declarations**

**List of abbreviations:** UNESCO & WHC: United Nations Educational, Scientific and Cultural Organization& World Heritage Centre; CITES: Convention on International Trade in Endangered Species; GoK: Government of Kenya

**Ethics Approval and consent to participate:** The research permit was obtained from National Commission for Science, Technology and Innovation (NACOSTI) in Kenya (Ref No. NACOSTI/P/18/59631/20783). Prior to data collection we reported to the County Commissioners and the County Directors of Education in Kajiado and Makueni Counties for final authorization in conducting the research.

The data collection in both Kajiado and Makueni Counties were done from May-November 2018 where the Chiefs in both counties were consulted of the initial meetings with communities, to clarify the aims and objectives of the study as well as determine the informants who had knowledge of plants. Each participant was presented with a consent form (approved by the Kenyatta National Hospital-University of Nairobi Ethics Research Committee (KNH-UoN ERC) which clarified the objectives of the study, and all informants were asked to sign consent forms to secure informed consent to participate in the study. A total of 393 people were contacted for interviews, and 384 (232 men and 152 women) agreed to sign a Free Consent form and be interviewed about their knowledge on use and management of East African Sandalwood.

**Consent for publication:** Not applicable

**Availability of data and material:** The collected data was not deposited in any public repositories.

**Competing interests:** The authors declared no conflicting interests.

**Funding:** This study was funded by the Social Sciences and Humanities Research Council of Canada, and supported by The King’s University, Edmonton, Canada and the University of Nairobi, Nairobi, Kenya.

**Author’s contributions:** JGM carried out fieldwork, data analysis and drafted the manuscript. HS and JTN configured the research project, supervised the work, and improved the manuscript. All the authors read, reviewed, and approved the final version of the manuscript.

**Acknowledgements**

We are grateful to the Kamba and Maasai Communities in Makueni and Kajiado Counties for their hospitality during the fieldwork. Also, our sincere gratitude is extended to the Social Sciences and Humanities Research Council of Canada in conjunction with Kings University, Edmonton, Canada and University of Nairobi, Kenya for funding this research. We are also appreciative to the many research participants and Chiefs in Kajiado and Makueni Counties for their guidance.

**Literature cited**

Adewoyin Y, Mokwenye, EM, Ugwu NV. 2020. Environmental ethics, religious taboos and the Osun-Osogbo grove, Nigeria. Journal of Cultural Heritage Management and Sustainable Development 1-13.
Albuquerque U, Hanazaki N. 2009. Five problems in current ethnobotanical research-and some suggestions for strengthening them. Human Ecology 37:653-661.

Alexiades MN. 1996. Collecting Ethnobotanical Data. An Introduction to Basic Concepts and Techniques. In: Selected guidelines for Ethnobotanical Research: A Field Manual 53-94, Edited by MN Alexiades & JW Sheldon. The New York Botanical Garden, Bronx, New York, USA

Amsalu N, Amsalu G, Bezie IY, Fentahum M, Alemayehu AI, Amsalu. 2018. Use and Conservation of Medicinal Plants by Indigenous People of Gozamin Wereda, East Gojam zone of Amhara Region, Ethiopia: An Ethnobotanical Approach. Hindawi Evidence-Based Complementary and Alternative Medicine 23.

Arévalo-Marín E, Lima JR de F, Palma ART, de lucena R FP, da Cruz DD. 2015. Traditional knowledge in a rural community in the semi-arid region of Brazil: Age and gender patterns and their implications for plant conservation. Ethnobotany Research and Applications 14: 331-344.

Atakpama W, Batawila K, Gnamkoulamba A, Akpagana K. 2015. Quantitative approach of Sterculia setigera Delile (Malvaceae) ethnobotanical uses among rural communities in Togo (West Africa). Ethnobotany Research and Applications 14:63-80.

Atreya K, Pyakurel D, Thagunna KS, Bhatta L, Upreti Y, Chaudhary R. 2018. Factors contributing to the decline of traditional practices in communities from the Gwallek-Kedari area, Baitadi, Kailash Sacred Landscape, Nepal. Environmental Management.

Baldermann S, Blagojevic L, Frede K, Klopfch R, Neugart S, Neumann A. 2016. Are Neglected Plants the Food for the Future? Critical Reviews in Plant Sciences 35(2):106-119.

Balima LH, Nacoula BM, Ekue MR, Kouame FN, Thiombiano A. 2018. Use patterns, use values and management of Afzelia africana Sm. in Burkina Faso: Implications for species domestication and sustainable conservation. Journal of Ethnobiology and Ethnomedicin 14(23):1-14.

Bhandari PS, Bhandari R, Sah BK, Gyawali S, Bhusal M, Shakya S. 2017. Antibacterial activity of methanolic extract of Mangifera indica (bark) and Osyris lanceolata (leaves) from Western Region of Nepal. World Journal of Pharmarcy and Pharmaciental Sciences 6(6):1778-1792.

Bunei EK. 2017. The hunt for the precious wood Illegal trade of sandalwood as an international criminal enterprise in Kenya. Society and Business Review 12(1):63-76.

Chivenge P, Mabhaudhi T, Modl AT. 2015. The Potential Role of Neglected and Underutilised Crop Species as Future Crops under Water Scarce Conditions in Sub-Saharan Africa. International Journal of Environmental Research and Public Health 12:5685-5711.

CITES. 2013. Convention on International Trade in Endangered Species of wild fauna and flora (CoP16 Prop. 69). Consideration of proposals for amendment of appendices I and II. In Sixteenth meeting of the Conference of the Parties Bangkok (Thailand), 3-14 March 2013. http://www-newsits.com/goto/http://www.cites.org/eng/cop/16/propE-CoP16-Prop-43.pdf

CITES (Convention on International Trade in Endangered Species of wild fauna and flora). 2013. Inclusion of East African Sandalwood Osyris lanceolata in Appendix 11. Convention on International Trade in Endangered Species of Wild Fauna and Flora.

Colding J, Folke C. 2001. Social taboos "invisible" systems of local resource management and biological conservation. Ecological Applications 11:584-600.

Constant NL, Tshikihwa MP. 2018. Hierarchies of knowledge: ethnobotanical knowledge, practices and beliefs of the Vhavenda in South Africa for Biodiversity Conservation. Journal of Ethnobiology and Ethnomedicine 14(56):1-28.

Creswell JW. 2014. Research Design: Qualitative, Quantitive and Mixed Methods Approaches (4th edn.). CA, Sage, Thousand Oaks.

Dapar MLG, Meve U, Liede-Schumann S, Alejandro GJD. 2020. Ethnomedicinal plants used for the treatment of cuts and wounds by the Agusan Manobo of Sibagat, agusan del sur, Philippines. Ethnobotany Research and Applications 19.
Dawang SN, Danahap TS, Makvereng SS, Nyam MA. 2016. Preliminary Survey of the Indigenous Knowledge of *Canarium schweinfurthii* Engl. (Atile) In Some Parts of Plateau State, Nigeria. IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS) 2(3):76-82.

Erasmus LJ, Potgieter MJ Semenya SS. 2015. Erectile dysfunction: Definition and material medica of Bapedi traditional healers in Limpopo Province, South Africa. Journal of Medical Plants Research 9(3):71-77.

Eshetu GR, Dejene TA, Tellia LB, Bekele DF. 2015. Ethnoveterinary medicinal plants: Preparation and application methods by traditional healers in selected districts of Southern Ethiopia. Veterinary World 8(5):674-684.

Etongo D, Djenantin IN, Kanninen M, Glover EK. 2017. Assessing use-values and relative importance of trees for livelihood values and their potentials for environmental protection in Southern Burkina Faso. Environmental Development and Sustainability 19(4):1141-1166.

Gathara M, Makenzi P, Kimondo J, Muturi G. 2014. Prediction of *Osyris lanceolata* (Hochst. & Steud.) site suitability using indicator plant species and edaphic factors in humid highland and dry lowland forests in Kenya. Journal of Horticulture and Forestry 6:99-106.

Geng Y, Zhang Y, Ranjitkar S, Huai H, Wang Y. 2016. Traditional knowledge and its transmission of wild edibles used by the Naxi in Baidi Village, North West Yunnan Province. Journal of Ethnobiology and Ethnomedicine 12(10):1-21.

Girma S, Giday M, Erko, B., Mamo, H. 2015. Effect of crude leaf extract of *Osyris quadrifolia* on *Plasmodium berghei* in Swiss albino mice. BMC Complementary and Alternative Medicine 15(184).

Global Plants. 2016. *Osyris lanceolata* Hochst. & Steud. [family Santalaceae]. Retrieved February 23, 2016.

GoK (Government of Kenya). 2010. Population and Housing Census. Nairobi: Government Printer, Nairobi.

GoK (Government of Kenya). 2013a. Makueni County Integrated Development Plan 2013-2017. Government Printer, Nairobi, Kenya.

GoK (Government of Kenya). 2013 b. Kajiado County Integrated Development Plan. Nairobi: Government Printer, Kenya.

Goudégnon EO, Vodouhe FG, Gouwakinnou GN, Salako VK, Oumorou M. 2017. Ethnic and generational differences in traditional knowledge and cultural importance of *Lannea microcarpa* Engl. & K. Krause in Benin's Sudanian Savannah. Bois et Forets Des Tropiques 334(4):49-59.

Groves, M., & Rutherford, C. (2016). CITES Timber. Kew Publishing Royal Botanic Gardens, Kew.

Hilonga S, Otieno JN, Ghorbani A, Pereus D, Kocyan A, de Boer H. 2019. Trade of wild-harvested medicinal plant species in local markets of Tanzania and its implications for conservation. South African Journal of Botany 122: 214-224.

IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

Kamondo B, Chahilu O, Gitehi G, Kariuki J. 2012. Collection, handling and germination of *Osyris lanceolata* seeds: Guidelines for farmers and extension agents. Nairobi, Kenya: Kenya Forestry Research Institute.

Kanui TI, Kibwage JK, Murangiri MR. 2016. Water tower ecosystems services and diversification of livelihood activities to neighbouring communities; A case study of Chyullu Hills water tower in Kenya. Journal of Geography, Environment and Earth Sciences International 6(4):1-12.

Kariuki PM, Lukhoba CW, Onyango CM, Njoka JT. 2018. The Trade in Wild Medicinal Plants, Narok County, Kenya. Applied Ecology and Environmental Sciences 6(4):118-127.

Kefalew A, Asfaw Z, Kelbessa E. 2015. Ethnobotany of medicinal plants in Ada’a District, East Shewa Zone of Oromia Regional State, Ethiopia. Journal of Ethnobiology and Ethnomedicine 11(1):1.

Kewessa G, Abebe T, Demessie A. 2015. Indigenous knowledge on the use and management of medicinal trees and shrubs in Dale District, Sidama Zone, Southern Ethiopia. Ethnobotany Research and Applications 14:171-182.

Kimondo J, Miaron J, Mutai P, Njogu P. 2015. Ethnobotanical survey of food and medicinal plants of the Ilkisonko Maasai community in Kenya. Journal of Ethnopharmacology 175:463-469.
Kiringe JW, Mwaura F, Wandera P, Kimeu M, Gachuga F. 2015. Water management tools in the Chyulu Hills Watershed. Report prepared for the African Wildlife Foundation (AWF) by Habitat Planners. Nairobi, Kenya.

Kiringe JW, Mwaura F, Warinwa, F. 2016. Characterization of Chyulu Hills Watershed Ecosystem Services in South-Eastern Kenya. Environment and Natural Resources Research 6(3): 65.

Kiringe JW, Mwaura F, Wandera P, Kimeu M, Gachuga F. 2015. Water management tools in the Chyulu Hills Watershed. Report prepared for the African Wildlife Foundation (AWF) by Habitat.

KNBS. 2010. 2009 Kenya Population and Housing Census. Nairobi, Kenya.

Kokwaro JO. 2009. In: Medicinal Plants of East Africa (3 Ed.) Nairobi: University of Nairobi Press.

Kosoe EA, Adjei POW, Diawuo F. 2020. From sacrilege to sustainability: the role of indigenous knowledge systems in biodiversity conservation in the Upper West Region of Ghana. GeoJournal 85(4): 1057-1074.

Kumari R, Kumar A, Kumar B. 2019. Ethnobotanical Investigation of Medicinal Plants used by Rural Communities of District Chatra, Jharkhand, India. IOSR Journal of Biotechnology and Biochemistry (IOSR-JBB) 5(6):34-49.

Kunwar RM, Fadiman M, Cameron M, Bussmann RW, Thapa-magar KB, Rimal B. 2018. Cross-cultural comparison of plant use knowledge in Baitadi and Darchula districts, Nepal Himalaya. Journal of Ethnobiology and Etnomedicine 14(40):1-17.

KWS (Kenya Wildlife Service). 2008. Tsavo Conservation Area Management Plan. Nairobi, KWS, Nairobi.

Lourens JCE, Matherienus JP, Sebua SS. 2015. Erectile dysfunction: Definition and materia medica of Bapedi traditional healers in Limpopo province, South Africa. Journal of Medicinal Plants Research 9(3):71-77.

Masango CA. 2020. Indigenous knowledge codification of African traditional medicine: Inhibited by status quo based on secrecy? Information Development 36(3):327-338.

Masevhe NA, McGaw LJ, Eloff JN. 2015. The traditional use of plants to manage candidiases and related infections in Venda, South Africa. Journal of Ethnopharmacology 168:364-372.

Mbunde MV, Innocent E, Mabiki F, Andersson PG. 2017. Ethnobotanical survey and toxicological evaluation of medicinal plants used for fungal remedy in the Southern Highlands of Tanzania. Journal of Intercultural Ethnopharmacology 6(1):84-96.

Mcpherson JM, Sammy J, Sheppard DJ, Mason JJ, Brichieri-Colombi TA. 2016. Integrating traditional knowledge when it appears to conflict with conservation: lessons from the discovery and protection of Sitatunga. Ecology and Society 21(1):24.

Misongo OJ, Kamindu GN, Sabina W, Muita, GM. 2019. An ethnobotanical survey of plants used for the treatment and management of cancer in Embu County, Kenya. Journal of Medicinal Plant Studies 7(4):39-46.

Moichwanetse BI, Ndhlovu PT, Sedupane G, Aremu AO. 2020. Ethno-veterinary plants used for the treatment of retained placenta and associated diseases in cattle among Dinokana communities, North West Province, South Africa. South African Journal of Botany 132:108-116.

Mukonyi KN, Kyalo S, Lubia I K, Leitore E, Mbaka RM, Mutungi PM. 2012. Status and distribution of East African Sandalwood (Osyris lanceolata) in Kenya. Kenya Wildlife Service Report.

Muriuki G, Leonie S, Clive M, Chris J, Browny P, Greg B. 2011. Land Cover Change under unplanned human settlements. A study of Chyulu Hills squatters, Kenya. Landscape and Urban Planning 99(2):154-165.

Murphy C, Tembo M, Phiri A, Yerokun O. Grymmell, B. 2016. Adapting to climate change in shifting landscapes of belief. Climate Change 134:101-114.

Muthee JK, Gakuya DW, Mbaria JM, Kareru PG, Mulei CM, Njongo FK. 2011. Ethnobotanical study of anthelmintic and other medicinal plants traditionally used in Loitoktok district of Kenya. Journal of Ethnopharmacology 135(1):15-21.

Mutisya MD, Mwizini M, Patrick KD. 2019. Socio-economic Benefits and the Associated Environmental Degradation Effects of Osyris lanceolata (Hochst & Steudel) Utilization in Kitui County, Kenya. Scientific Research Journal VII(1v):1-19.
Mwang’ingo PL, Teklehaimanot Z, Lulandala LL, Mwihomeke ST. 2005. Host plants of *Osyris lanceolata* (African Sandalwood) and their influence on its early growth performance in Tanzania. South African Forestry Journal 203:55-65.

Njoroge G, Bussmann, R. 2006. Diversity and utilization of antimalaria ethnophytotherapeutic remedies among the Kikuyus (Central Kenya). Journal of Ethnobiology and Ethnomedicine 2(8).

Njoroge GN, Bussmann RW. 2006. Diversity and utilization of antimalaria ethnophytotherapeutic remedies among the Kikuyus (Central Kenya). Journal of Ethnobiology and Ethnomedicine 2:1-7.

Nyahangare ET, Mvumi BM, Mutibvu T. 2015. Ethnoveterinary plants and practices used for ecto-parasite control in semi-arid smallholder farming areas of Zimbabwe. Journal of Ethnobiology and Ethnomedicine 11(1).

Ochanda VK. 2010. Conservation and Management of sandalwood trees: (*Osyris lanceolata* Hochst & Steudel,) in Chyulu Hills Kibwezi District, Kenya. Msc Thesis. Kenyatta University, Kenya.

Omara T. 2020. Antimalarial Plants Used across Kenyan Communities. Hindawi Evidence-Based Complementary and Alternative Medicine 1-31.

Omona J. 2013. Sampling in qualitative research: Improving the quality of research outcomes in higher education. Makerere Journal of Higher Education 4(2):169-185.

Ooko EA. 2009. Evaluation of Anti-microbial activity of *Osyris lanceolata* (East African Sandalwood). JKUAT Abstracts of Post Graduate Thesis. Retrieved May 04, 2015.

Orech FO, Schwarz JG. 2017. South African Journal of Botany Ethno-Phyto therapeutic remedies used in meat, milk, and blood products by the Maasai people of Kenya. South African Journal of Botany 108:278-280.

Orw a C, Mutua A, Kindt R, Jamnadass R, Simons A. 2009. *Osyris lanceolata* Agroforestry Database: a tree reference and selection guide version 4.0. Hochst. & Steud. ex A. DC. Santalaceae.

Oti enjo J, Abihudi S, Veldman S, Nahashon M, van Andel T, de Boer H. 2015. Vernacular dominance in folk taxonomy: a case study of ethnospesies in medicinal plant trade in Tanzania. Journal of Ethnobiology and Ethnomedicine 11(10).

Page T, Tate H, Bunt C, Potrawiak A, Berry A. 2012. Opportunities for the smallholder sandalwood industry in Vanuatu. Canberra.

Paniagua-Zambrana NY, Camara-Leret R, Bussman RW, Macia MJ. 2014. The influence of socio-economic factors on traditional knowledge a cross scale comparison of palm use in North Western South America. Ecology and Society 19(4):9.

Paudel PN, Gyawali R. 2014. Phytochemical Screening and Antimicrobial Activity of Some Selected Medicinal Plants of Nepal. International Journal of Pharmaceutical and Biological Archives 5(3):84-92.

Prelude Medicinal Plants Database. 2013. Prelude Medicinal Plants Database. Retrieved from Ethnomedical information on *Osyris lanceolata*.

Rajbanshi N, Thapa LB. 2019. Traditional knowledge and practices on utilizing medicinal plants by endangered Kisan ethnic group of Eastern Nepal. Ethnobotany Research and Applications 18:1-9.

Rankoanna SA. 2016. Sustainable Use and Management of Indigenous Plant Resources: A Case of Mantheding Community in Limpopo Province, South Africa. Sustainability 3(221):2-13.

Rasethe MT, Semenya SS, Potgieter MJ, Maroyi A. 2013. The utilization and management of plant resources in rural areas of the Limpopo Province, South Africa. Journal of Ethnobiology and Ethnomedicine 9(27).

Reid R, Gachimbi L, Worden J, Wangui S, Mathai S. 2004. Linkages between changes in land use, biodiversity and land degradation in the Loitokitok Area of Kenya. Land use change impacts and dynamics (LUCID) Working Paper Series 49: 1-29

Salako KV, Moreira F, Gbedomon R C, Tovissode F, Assogbadjo AE, Kakai RL. 2018. Traditional knowledge and cultural importance of *Borassus eathiopium* Mart.In Benin: interacting effects of sociodemographic attributes and multi-scale abundance. Journal of Ethnobiology and Ethnomedicine 14(36):1-16.
Sharma A, Thakur D, Uniyal SK. 2021. Taboos: Traditional beliefs and customs for resource management in the Western Himalaya. Indian Journal of Traditional Knowledge 20(2):575-581.

Shyaula SL. 2012. A review on genus Osyris: Phytochemical constituents and traditional uses. Journal of Natural Pharmaceuticals 3:61-70.

Sombroek WG, Braun HM, Pouw, BJ. 1982. Exploratory soil map and agroclimatic zone map of Kenya. Nairobi.

Ssebunya M, Okyere-Manu B. 2017. Moral responsibility and environmental conservation in Karamoja mining area: towards a religious engagement. Journal for the Study of Religion 30(2):90-104.

Subba B, Srivastav C, Chandra RK. 2016. Scientific validation of medicinal plants used by Yakkha community of Chanuwa VDC, Dhankuta, Nepal. Springer Plus 5(155).

Teka A, Asfaw Z, Demissew S. 2020. Traditional medicinal plant use of indigenous communities in Gurage zone, Ethiopia. Ethnobotany Research & Applications 19(41):1-31.

Texeira Da Silva JA, Kher MM, Soner D, Nataraj M. 2016. African Sandalwood or Nepalese Sandalwood: A Brief Synthesis. Notulae Science Biologicae 8(1):57-61.

The Plant List. 2016. Osyris lanceolata Hochst & Steud. Retrieved February 23, 2016, from the plant list.

Umair KM, Altaf M, Abbasi LM. 2017. An ethnobotanical survey of indigenous medicinal plants in Hafizabad district, Punjab-Pakistan. PLoS One 12(6): e0177912.

UNESCO & WHC (United Nations Educational, Scientific and Cultural Organization & World Heritage Centre). 2010. UNESCO and WHC. Retrieved from UNESCO and WHC Website.

Wanjohi BK, Njenga EW, Sudio V, Kipkore, WK, Moore, HL, Matthew IJ. 2020. Ecological Knowledge of indigenous plants among the Marakwet Community (Embobut Basin), Elgeyo Marakwet County (Kenya). Ethnobotany Research & Applications 20(1):1-16.

William OO. 2010. Plant story-a very useful plant, Osyris lanceolata is at risk of extinction due to overexploitation. In: Kew R Botanical Garden.

Wilson B. 2018. Osyris lanceolata. In The IUCN Red List of Threatened Species 2018: e.T200642A2675362. http://dx.doi.org/10.2305/IUCN.UK.2018-1.RLTS.T200642A2675362 (Vol. 8235).

Yeboah EMO, Majinda RRT. 2013. Five new agarofuran sesquiterpene polyesters from Osyris lanceolata. Phytochemistry Letters 6(4):531-535.

Zent S. 1999. The quandary of conserving ethnoecological knowledge-a Piaroa example. (e. E.-k. in T.L. Gragson and B. G. Blount, Ed.) University of Georgia Press, Athens, Georgia, USA.