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Original Article

Traditional Uses and Ex-Situ Conservation of Warburgia ugandensis around Katimok Forest Reserve, Kenya

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ABSTRACT

Different tree species provide a wide range of local livelihood options, including firewood, timber, and medicinal uses, among others. Specifically, traditional medicine significantly contributes to primary health care with a sizable number of people heavily depending on traditional medicine, while many others have used medicinal plants at one time or another. For instance, Warburgia ugandensis is mainly utilised for its medicinal value in many rural areas. Furthermore, people living in rural areas depend on the herbal medical system due to their firm beliefs and limited access to allopathic medicine. Traditionally, indigenous plant species are used to treat diseases that affect both humans and livestock. Consequently, the wide use of medicinal plants such as Warburgia ugandensis has increased commercial collection, unregulated trade, and habitat loss, with the imminent danger of the plant species being threatened. To further compound the problem, few or no medicinal plant species are cultivated on farms. Therefore, the study aimed to analyse traditional uses and examine ex-situ conservation measures of Warburgia ugandensis around Katimok Forest Reserve in Baringo County, Kenya. The primary data was collected using household survey questionnaires and key informant interviews. The key informant interviews and household surveys were done by randomly sampling 345 respondents. One-way ANOVA and SPSS version 28.0.1 were used to analyse the data. Tables, charts and a histogram were used to present data in frequencies and percentages. All the statistics were considered at 95% confidence levels. The results revealed a significant difference in existing ex-situ conservation measures (F (2,9) =63.55, P-Value=4.92) and traditional uses of Warburgia ugandensis in the study blocks around Katimok Forest Reserve (F (3,12) = 109.66, P-Value=5.49). Medicinal use is the most predominant among the other uses. Additionally, there are limited ex-situ conservation measures for important plant species. Therefore, there is an immediate need to promote the ex-situ conservation of invaluable medicinal plant species to enhance the sustainability of traditional uses.

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INTRODUCTION

All over the world, there are tens of thousands of medicinal plant species (Marrelli, 2021). The International Union for Conservation of Nature and the World Wildlife Fund (Chen *et al*., 2016) identified between 50,000 and 80,000 flowering plants that have medicinal value globally. In the Himalaya Region of India, which is a global biodiversity hotspot, there are close to 2,000 medicinal plant species identified (Sofi *et al*., 2022). According to Šatović *et al*. (2012), there are 800 plant species with traditional uses in the Amazon region of Brazil, comprising fruit trees, oil-producing trees, and hundreds of medicinal trees. Africa has a vast repository of plant biodiversity, with more than forty thousand known vascular plant species, many of which are used in traditional medicine (Mahomoodally, 2013). The family *Canellaceae* is the most commonly traded and consumed plant species in Sub-Saharan Africa (Muchugi et al., 2012b). The genus *Warburgia* belongs to this family and occurs primarily in South Africa and Eastern Africa. The specific countries where the wealth of these species is found include South Africa, the Democratic Republic of Congo, Kenya, Uganda, Ethiopia, and Tanzania (Dokata *et al*., 2023).

According to Jamil (2022), overharvesting and habitat destruction due to population growth and increased plant consumption are threatening the existence of these valuable plant species. Many countries face forest destruction, land degradation, and loss of biodiversity (Yismaw & Tadesse, 2018). In Kenya, a host of native tree species, including important medicinal tree species, faces threats of extinction due to shifting agriculture and wood harvesting (Harvey-Brown & Shaw, 2020). Despite these alarming threats of extinction for these medicinal plant species, there are no or few existing conservation plans (Painuli *et al*., 2021). The available population of medicinal plants is mostly found growing inside forests, at the edge of the forest, and in the intermediate surroundings outside forests (Otieno & Analo, 2012).

However, some ex-situ conservation of trees has been established to address the challenges of high rural poverty, food insecurity, and loss of biodiversity (Zinngrebe et al., 2020). Various stakeholders, such as the government and international donors, have funded on-farm tree-growing projects as one of the tools for improving the welfare of rural communities. In the wake of climate change, on-farm forestry has evolved to include carbon forestry, with the dual purpose of sequestering carbon and improving rural livelihoods (Kiyingi et al., 2016). Warburgia ugandensis is a highly important medicinal species with a wide range of antimicrobial activities (Senkoro et al., 2020; Painuli et al.,

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2021). There are parts of the tree species, specifically stem barks and leaves, that are used in the management of many disorders and protection against health conditions such as cough, cold, respiratory, and odontological ailments among many communities in Kenya (Abuto et al., 2018). Apart from using the species for the treatment of diseases, there are other expansive uses ranging from harvesting livestock feeds, timber, poles, charcoal, and firewood. These wide swaths of uses have significantly decimated the tree population (Abuto et al., 2018). A previous study by Muchugi (2012a) emphasised the urgent need for developing and implementing conservation strategies for this species and information on genetic structure as a crucial input.

MATERIALS AND METHODS

Study Area

This study was conducted within four sub-locations adjacent to Katimok Forest Reserve (KFR) in Baringo County, Kenya. The forest reserve was gazetted in 1949, and it is currently being managed by the Baringo County Government (Dokata *et al*., 2023). The elevation of the sub-locations ranges between 2162 m and 2288 m above sea level and lies on latitudes 00° 59'N - 00° 38'N and longitudes 35° 32'E - 35° 39'E. The study area receives an annual rainfall of about 1000–1500 mm and mean annual temperatures ranging from a minimum of 10 ^{0}C and a maximum of 30 °C (Ednah *et al*., 2018). The sub-locations surrounding Katimok Forest Reserve include Talai, Ossen, Kelyo (Kabartonjo) and Saimo. The 2019 census report indicates that the total population in these sub-locations surrounding the forest was about 29,000 people (KNBS, 2019).

Sample Size Determination

The number sample size (n) was calculated using the Yamane formula (1967): The formulae allow the determination of sample size, which has characteristics the same as the population (Uakarn, 2021).

n = [z2 * p * (1 - p) / e2] / [1 + (z2 * p * (1 - p) / (e2 * N))].

Where: z = 1.96 for a confidence level (α) of 95%, p = proportion (expressed as a decimal), N = population size, e = margin of error.

z = 1.96, p = 0.35, N = 29000, e = 0.05

n = [1.962 * 0.35 * (1 - 0.35) / 0.052] / [1 + (1.962 * 0.35 * (1 - 0.35) / (0.052 * 29000))]

n = 349.5856 / 1.0121 = 345.422 = 345

The sample size was therefore, 345.

The respondents were proportionately distributed across the four sub-locations neighbouring Katimok Forest Reserve. This was done by dividing the population of each sub-location by the total population of the four sub-locations and finally multiplying the results by the total number of respondents (Population of a sub-location / 29000 * 345). Households which were living close to the forest, preferably not more than 3 km from the forest edge were picked randomly using systematic simple random sampling within each sub-location to administer the questionnaires. The different sub-locations' sample size distribution is detailed below (*Table 1*).

Table 1: Sample size distribution

Village/sub location	Population	Sample
Kabartonjo	7900	93
Ossen	6100	73
Saimo	5800	68
Talai	9200	111
Total	**29000**	**345**

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In addition, key informant interviews were conducted with 15 herbalists, 2 tree nursery owners and 2 foresters purposively sampled.

Data Analysis

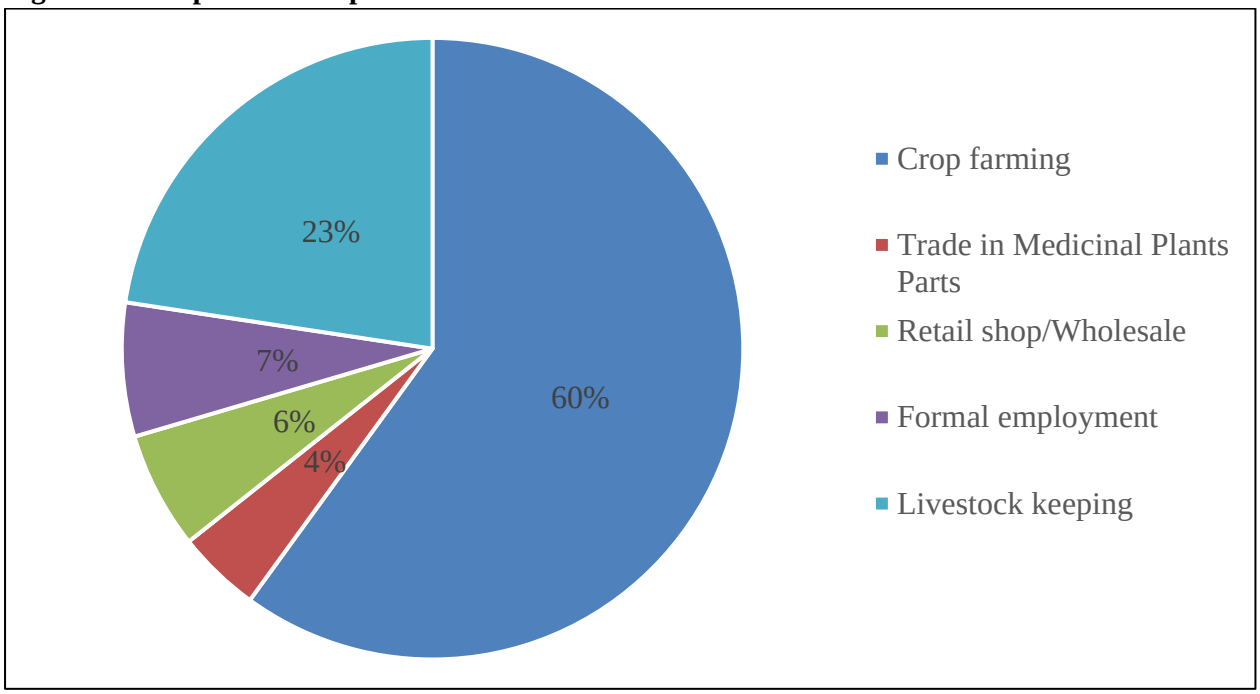
After data collection and compilation, Analysis of Variance (One Way ANOVA) was used to compute the difference in the traditional uses and *ex-situ* conservation measures of *Warburgia ugandensis.* Further, SPSS version 28.0.1 was used to present descriptive statistics that included tables and charts. All the statistical significances were considered at 95% confidence levels.

RESULTS AND DISCUSSIONS

Respondents Occupation

The study revealed that crop farming and livestock keeping were the leading livelihood activities at 60% and 23%, respectively. Whole and retail shop businesses and Formal employment accounted for 6% and 7%, respectively. Lastly, the results indicated that trade in medicinal plant parts was an important economic activity, with 4% of the respondents engaged in its sales as their main livelihood activity (*Figure 1*).

Figure 1: Occupation of respondents around Katimok Forest Reserve



The findings are consistent with a study (Brown *et al*., 2006) which showed crop farming and livestock rearing as sustainable livelihood strategies in rural Kenyan highlands. Moreover, previous studies (Mbuni *et al*., 2020) found that more than 70% of Kenyans rely on herbal remedies as their first sources of medicine, thereby explaining why there are people involved in the sale of medicinal plant parts as their main livelihood activity.

The Traditional uses of *Warburgia ugandensis*

The study revealed that 81% of the respondent use *Warburgia ugandensis* for medicinal purposes, while about 10% reported its use as poles, 5% as fuelwood, and 4% indicated it as food (especially fruits which are consumed by animals). The disaggregation of the main traditional uses of *Warburgia ugandensis* per study block is detailed below (*Table 2*).

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Table 2: The Traditional uses of *Warburgia ugandensis* in Baringo County

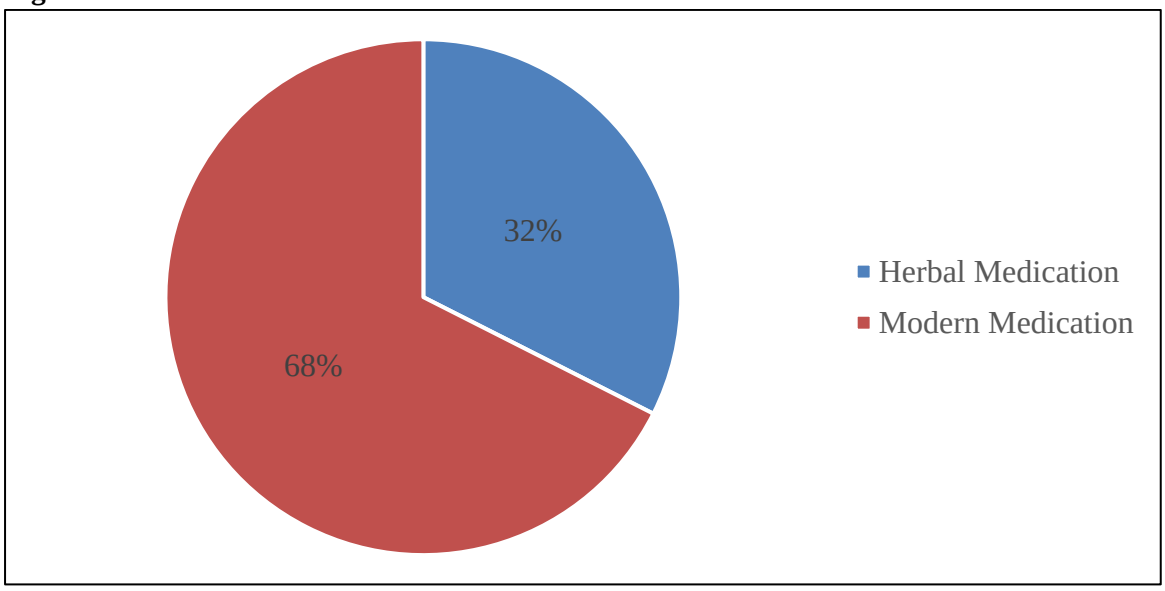
Study Block	Medicinal	Timber/Poles	Charcoal/firewood	Food/feed
Ossen	61	4	5	3
Kabartonjo	74	12	4	3
Talai	82	17	7	5
Saimo	61	2	3	2
Per cent (%)	81%	10%	5%	4%

The one-way ANOVA showed a significant difference in socio-economic uses of *Warburgia ugandensis* in all the study blocks ($F_{(3,12)}$ = 109.66, P-Value=5.49). The major socio-economic of *Warburgia ugandensis* revealed by the study was medicinal. The respondents noted that *Warburgia ugandensis* is used to treat several ailments in the study community. They cited the use of tree species parts in the treatment of malaria, toothache, chest congestion and stomach ache, among other uses. They also elaborated that mature *Warburgia ugandensis* provide quality timber needed for construction purposes. These results are consistent with other studies that the tree is being over-harvested mainly because of its medicinal value as opposed to other traditional uses (Delvaux *et al*., 2009). Besides, an estimated 80% of Kenya's rural population depends on medicinal plants for medication (Nankaya *et al*., 2021). Furthermore, another study cited the antimicrobial activities of *Warburgia ugandensis* species, thus its wide use in the management of health conditions such as cough, cold, respiratory and odontological ailments among many communities in Kenya (Abuto *et al*., 2018).

Forms of Medication

The number of respondents using herbal medication accounted for 32% and those who preferred modern medication were 68% as shown in *Figure 2*.

Figure 2: Forms of Medication



The major reason for the use of herbal medicine, according to respondents, was that modern medicines are relatively expensive when compared to local herbs. Moreover, scientific work validating therapeutic claims on herbal plants continues to increase (Gakuya *et al*., 2020). According to the study, a small number of respondents who prefer traditional medicine said they resort to modern medicine when they do not recuperate after treatment administered by traditional medicine practitioners. This is consistent with an earlier study (Tomlinson &

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Akerele, 2015) indicating that across the globe, the push to reduce the cost of health care has made herbals and botanicals a favourable alternative to more expensive synthetic remedies. Notably, interviewees had a general feeling that traditional medication may turn out to be the best form of medication, especially in the wake of the COVID-19 pandemic and other emerging diseases.

Parts of *Warburgia ugandensis* Harvested by the Local Community

The results indicated that the most commonly harvested part for herbal medicine is the bark (76%), the leaves (18%), stems or branches (5%) and fruits accounting for 1% of used parts. *Table 4* below shows the distribution of the most commonly extracted plant parts across the four selected study sites.

Table 3: *Warburgia ugandensis* parts most extracted

Study Block	Bark	Leaves	Stem/Branches	Fruits
Ossen	59	7	7	0
Kabartonjo	67	22	3	1
Talai	72	32	7	0
Saimo	64	1	1	2
Frequency	76%	18%	5%	1%

There was a significant difference in the *Warburgia ugandensis* parts commonly used within the different study blocks ($F_{(3,12)} = 60.17$, P-Value = 1.67). Bark and leaves were the most commonly used tree parts. Bark and leaves were mainly extracted for the treatment of various illnesses according to responses from interviewee participants. The respondents also clarified that stems and branches are very good poles for the construction of houses, thus necessitating harvesting of the parts. The fruits are least harvested and, when harvested, are eaten by domestic animals or seed removed for sowing on the farm or in tree nurseries. This concurs with the finding by Abuto (2018) that bark extracts displayed the highest antimicrobial activity compared to leaf extracts, regardless of the extracting solvents. Further findings by Maobe *et al*. (2013) cited antimicrobial activities of leaf decoction of *Warburgia ugandensis* species, thus its wide use in the management of health conditions such as cough, cold, respiratory and odontological ailments among many communities in Kenya.

Existing *Warbugia ugandensis Ex-Situ* Conservation Measures

According to household survey results, the farmers do little to grow the tree species. Those who do not have the tree species growing on their farms accounted for 92.5% of the respondents. The distribution of respondents without the tree species on their farms were 18.8%, 23.2%, 31.6% and 19.7% for Ossen, Kabartonjo, Talai and Saimo study blocks, respectively. The respondents who have the *Warburgia ugandensis* tree species on their farm accounted for 7.2%. The distribution of the respondents having the tree species on their farms was 2.3%, 3.8%, 0.6% and 0.6% for Ossen, Kabartonjo, Talai and Saimo study blocks, respectively. Lastly, only 0.3% of the respondent's stock *Warburgia ugandensis* seedlings (*Figure 3*).

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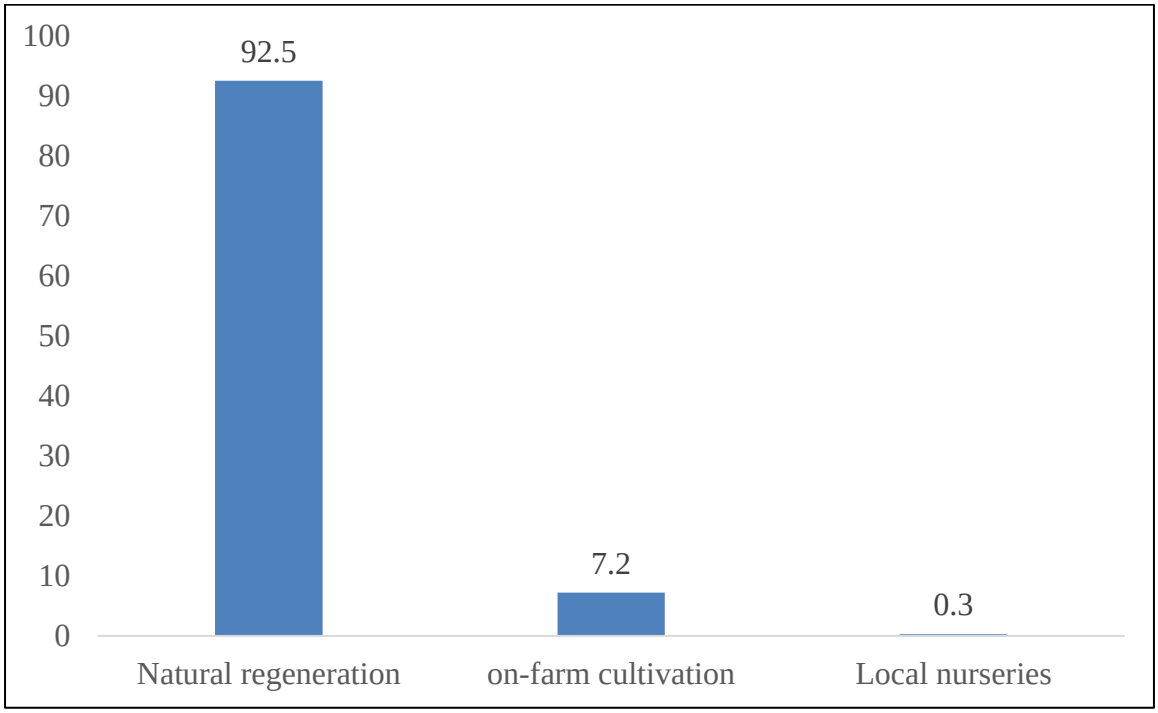
Figure 3: Ex-situ Conservation Measures of *Warburgia ugandensis* around Katimok Forest Reserve

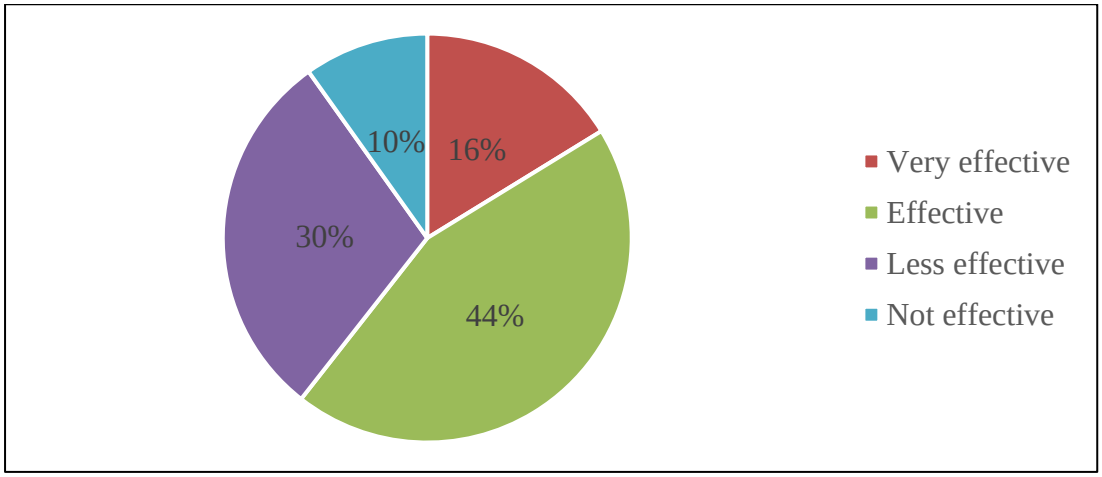


Analysis of the conservation of *Warburgia ugandensis* in the various study blocks indicated a significant difference in existing *ex-situ* conservation measures ($F_{(2,9)}$ =63.55, P-Value=4.92). The responses by interviewees clearly indicated minimal *ex-situ* conservation measures by the local communities. The majority of the respondents reported that it naturally regenerates. These findings corroborate a study by Chen (2016) that showed limited deliberate conservation strategies for medicinal plants. Equally**,** according to Marquard (2015), failure to grow medicinal plants on-farm would lead to unsustainable-farmed supplies of medicinal plant products and limited provision of alternative sources of income to farmers.

Status of *Ex-Situ* Conservation Measures

According to the results, the *ex-situ* conservation measures were 16% very effective, 44% effective, 30% less effective, while only 10% were reported as not effective (*Figure 4*).

Figure 4: Status of ex-situ Conservation of *Warburgia ugandensis*



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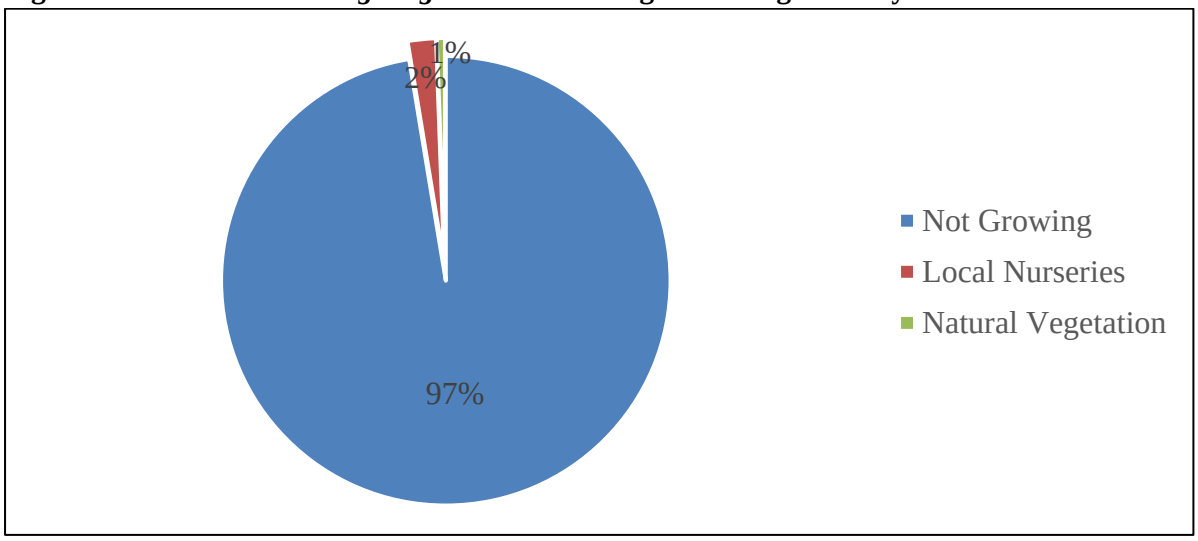
Concerns have been raised over the unsustainable harvesting of medicinal plant species as its demands are rising as people prefer to use natural medicinal plants to meet their health care needs (Nankaya *et al*., 2021). Previous research (Kumar, 2006) indicated an imminent threat to the survival of medicinal plant species worldwide, with a number of plant species being threatened, endangered or extinct. However, *ex-situ* conservation of medicinal plants including *Warburgia ugandensis* is reported to have been adversely affected by human activities, livestock grazing and wildfires (Gafna *et al*., 2017).

Source of *Warburgia ugandensis* Seedlings

The majority (97%) of the respondents reported that *Warburgia ugandensis* is a naturally growing tree species and that they do not plant seedlings on their farms. A paltry 2% of respondents indicated that the seedlings were being stocked by local nurseries and that they buy from the nurseries if necessary. Surprisingly, 1% of the respondents said they get wildings from natural vegetation to grow on their farms (*Figure 5*).

Figure 5: Sources of *Warburgia ugandensis* Seedlings in Baringo County



In Kenya, tree nursery establishment and management experience challenges such as the production of few species and the lack of knowledge, skills and resources necessary to set up and run a nursery (Nieuwenhuis & O'Connor, 2000). This explains why in Kabartonjo and Saimo the respondents cited a lack of nurseries that stock *Warburgia ugandensis* species as the reason why they were not cultivating *Warburgia ugandensis* on their farms. It is only the Kenya Forest Service nursery in Ossen that stocks *Warburgia ugandensis* seedlings. Additionally, tree nursery owners face challenges of water shortage, theft and market-related problems (Rutto & Odhiambo, 2017).

CONCLUSION

There are limited ex-situ conservation measures for *Warburgia ugandensis* despite its wide range of traditional uses. The study established that medicinal use is the most predominant traditional use in all the study blocks. Thus, there is an immediate need to promote ex-situ conservation programs for the plant species to enhance the sustainability of the traditional uses as well as boost the declining population of the plant species. Ex-situ conservation measures such as kitchen gardens, botanical gardens, and seed banks should be promoted in the study area. Finally, there is a need to promote the use of other medicinal plant parts (apart from *Warburgia ugandensis*) as well as encourage the use of modern medications to reduce over-reliance on

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Warburgia ugandensis tree species among the population in the study area.

REFERENCES

Abuto, J., Muchugi, A., & Machocho, A. (2018). Diversity in the Phytochemical Profiles of *Warburgia ugandensis* Sprague from Different Populations across the Kenyan Rift Valley Diversity in the Phytochemical Profiles of *Warburgia ugandensis* Sprague from Different Populations across the Kenyan Rift Vall. 3(May).

Brown, D., Stephens, E., Ouma, J., Murithi, F., & Barrett, C. B. (2006). Livelihood strategies in the rural Kenyan highlands. African Journal of Agricultural and Resource Economics, 1(1), 21– 36. http://ageconsearch.umn.edu/bitstream/57019/2/0101 Barrett - FINAL & Fr abstract 5 Mar.pdf%5Cnhttp://econpapers.repec.org/article/agsafjare/57019.htm

Chen, S. L., Yu, H., Luo, H. M., Wu, Q., Li, C. F., & Steinmetz, A. (2016). Conservation and sustainable use of medicinal plants: Problems, progress, and prospects. *Chinese Medicine (United Kingdom)*, *11*(1), 1–10. https://doi.org/10.1186/s13020-016-0108-7

Delvaux, C., Sinsin, B., Darchambeau, F., & Van Damme, P. (2009). Recovery from bark harvesting of 12 medicinal tree species in Benin, West Africa. *Journal of Applied Ecology*, *46*(3), 703– 712. https://doi.org/10.1111/j.1365-2664.2009.01639.x

Dokata, D. I., Mburu, B. K., Macharia, G. M., Choge, S. K., Ojunga, S. O., & Kaudo, B. O. (2023). Distribution, Conservation Status and Effects of Threats on Relative Abundance of *Warburgia ugandensis* Tree Species. A Case Study of Katimok Forest Reserve, Kenya. *East African Journal of Forestry and Agroforestry*, *6*(1), 1–17. https://doi.org/10.37284/eajfa.6.1.1044

Ednah, C. K., Jackson, J. K., & Charles, W. R. (2018). Analysis of spatial variability in rainfall trends in Baringo County, Kenya. *African Journal of Environmental Science and Technology*, *12*(9), 296–304. https://doi.org/10.5897/ajest2016.2214

Gakuya, D. W., Okumu, M. O., Kiama, S. G., Mbaria, J. M., Gathumbi, P. K., Mathiu, P. M., & Nguta, J. M. (2020). Traditional medicine in Kenya: Past and current status, challenges, and the way forward. *Scientific African*, *8*, e00360. https://doi.org/10.1016/j.sciaf.2020.e00360

Harvey-Brown, Y., & Shaw, K. (2020). Planning Conservation Action for Kenya's Threatened Trees.

Gafna, D., Dolos, K., O Mahiri, I., Mahiri, J. G., & Obando, J. A. (2017). Diversity of Medicinal Plants and Anthropogenic Threats in the Samburu Central Sub-County of Kenya. African Journal of Traditional, Complementary and Alternative Medicines, 14(5), 72– 79. https://doi.org/10.21010/ajtcam.v14i5.10

Jamil, A., Zubair, M., Manzoor, S. A., Muhammad, M. W., Yasin, G., Rahman, S. U., Alzain, M. N., Alqarawi, A. A., & Abd_Allah, E. F. (2022). Impact of Human Settlements on Diversity of Range Vegetation. *Sustainability (Switzerland)*, *14*(1), 1– 15. https://doi.org/10.3390/su14010519

Kiyingi, I., Edriss, A., Phiri, M., Buyinza, M., & Agaba, H. (2016). The Impact of Farm Forestry on Poverty alleviation and Food Security in Uganda. *Journal of Sustainable Development*, *9*(1), 150. https://doi.org/10.5539/jsd.v9n1p150

Kumar, P. (2006). The economics of medicinal plants: Are high commercial values enough to ensure biodiversity conservation? In Conserving Medicinal Species: Securing a healthy future.

Mahomoodally, M. F. (2013). Evidence - Based Complementary and Alternative Medicine Traditional Medicines in Africa: An Appraisal of Ten Potent African Medicinal

Article DOI: https://doi.org/10.37284/eajfa.6.1.1232

Plants. Evidence-Based Complementary and Alternative Medicine, 2013, 1–14. http://dx.doi.org/10.1155/2013/617459

Maobe, M. A. G., Gitu, L., Gatebe, E., & Rotich, H. (2013). Physical Evaluation of Selected Eight Medicinal Herbs Used for the Treatment of Diabetes, Malaria and Pneum Fire Preparedness View Project Waste water treatment View project. https://doi.org/10.5829/idosi.ejas.2013.5.2.65134

Marquard, H. (2015). Muliru Farmers: Cultivating traditional medicinal plants to protect the last Kenyan rainforest Muliru Farmers Cultivating traditional medicinal plants to protect the last Kenyan rainforest 2010 SEED Winner Founding Partners 2 Seed Case Study: Muliru Farmers Seed Case Studies Series Demonstrating Sustainable Development on the Ground Through Locally-driven Eco-entrepreneurship. https://doi.org/10.13140/RG.2.1.2756.6560

Marrelli, M. (2021). Medicinal plants. In *Plants* (Vol. 10, Issue 7). MDPI. https://doi.org/10.3390/plants10071355

Mbuni, Y. M., Wang, S., Mwangi, B. N., & Mbari, N. J. (2020). Western Kenya. *Plants*, *9*(331), 1–16.

Muchugi, A., Kindt, R., Muluvi, G. M., Muge, E., Kipruto, H., & Jamnadass, R. H. (2012a). Genetic Variation of Kenyan Populations of *Warburgia ugandensis*, an Important East African Highlands Medicinal Tree Species. Journal of Life Sciences, *4*(2), 97–105. https://doi.org/10.1080/09751270.2012.11885201

Muchugi, A., Kindt, R., Muluvi, G. M., Muge, E., Kipruto, H., & Jamnadass, R. H. (2012b). Genetic Variation of Kenyan Populations of *Warburgia ugandensis*, an Important East African Highlands Medicinal Tree Species. *Journal of Life Sciences*, *4*(2), 97–105. https://doi.org/10.1080/09751270.2012.11885201

Nankaya, J., Gichuki, N., Lukhoba, C., & Balslev, H. (2021). Prioritisation of Loita Maasai medicinal plants for conservation. *Biodiversity and Conservation*, *30*(3), 761–780. https://doi.org/10.1007/s10531-021-02116-8

Nieuwenhuis, M., & O'Connor, N. (2000). Challenges and opportunities for small-scale tree nurseries in the East African highlands. *Unasylva*, *51*(203), 56–60.

Otieno, N. E., & Analo, C. (2012). Local indigenous knowledge about some medicinal plants in and around Kakamega forest in western Kenya. *F1000Research*, *1*, 1–18. https://doi.org/10.12688/f1000research.1-40.v2

Painuli, S., Semwal, P., Cruz-Martins, N., & Bachheti, R. K. (2021). Medicinal Plants of Himalayan Forests. In *Non-Timber Forest Products* (pp. 175–212). Springer International Publishing. https://doi.org/10.1007/978-3-030-73077-2_8

Rutto, G. C., & Odhiambo, K. O. (2017). Socio-Economic Importance of Tree Nurseries in Eldoret Municipality, Uasin Gishu County (Kenya). *2017 AER Journal*, *2*(2), 146–154. http://www.aerjournal.info

Šatović, Z., Carović-Stanko, K., Grdiša, M., Jug-Dujaković, M., Kolak, I., & Liber, Z. (2012). Conservation of Medicinal and Aromatic Plants in Croatia. *NATO Science for Peace and Security Series C: Environmental Security*, *122*, 261–269. https://doi.org/10.1007/978-94-007-2953-7_24

Senkoro, A. M., Talhinhas, P., Simões, F., Batista-Santos, P., Shackleton, C. M., Voeks, R. A., Marques, I., & Ribeiro-Barros, A. I. (2020). The genetic legacy of fragmentation and overexploitation in the threatened medicinal African pepper-bark tree, Warburgia salutaris. *Scientific Reports*, *10*(1), 1–14. https://doi.org/10.1038/s41598-020-76654-6

Article DOI: https://doi.org/10.37284/eajfa.6.1.1232

Sofi, I. I., Verma, S., Ganie, A. H., Sharma, N., & Shah, M. A. (2022). Threat status of three important medicinal Himalayan plant species and conservation implications. *Nature Conservation Research*, *7*(1). https://doi.org/10.24189/ncr.2022.006

Tomlinson, T. R., & Akerele, O. (2015). Medicinal plants: Their role in health and biodiversity. In Medicinal Plants: Their Role in Health and Biodiversity.

Uakarn, C. (2021). Sample size estimation using Yamane and Cochran and Krejcie and Morgan and Green formulas and Cohen statistical power analysis by G*power and comparisons. *Apheit International Journal*, *10*(2), 76–88.

Volume I: Population By County And Sub-County Counting Our People for Sustainable Development and Devolution of Services REPUBLIC OF KENYA. (2019).

Yismaw, M. T., & Tadesse, D. B. (2018). The Contribution of Agro forestry System to Tree Biodiversity Conservation and Rural Livelihood: The Case of Lay Armachiho District, Gondar, Ethiopia. International Journal of Scientific Research and Management, 6(5), 129–139. https://doi.org/10.18535/ijsrm/v6i5.ah02

Zinngrebe, Y., Vidal, A., Gassner, A., Kumar, C., & Dobie, P. (2020). Trees on Farms as a Nature-based Solution for Biodiversity Conservation in Agricultural Landscapes. ICRAF Policy Brief, 2019(47). https://doi.org/10.13140/RG.2.2.14852.07045

