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Research article

Abundance and Threats to Medicinal Plants used in Managing Respiratory Illnesses in Migori County, Kenya: A need for increased local sensitization

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Abstract

Respiratory ailments afflict millions of people around the world, posing a significant health burden in many developing countries. In Kenya, many communities use diverse plant resources to treat various illnesses. However, the plant species population is fast diminishing due to over-exploitation. The study aimed to assess the abundance and evaluate threats and conservation measures for medicinal plants used in managing respiratory illnesses in Migori County. Semi-structured questionnaires were administered to 32 Traditional Health Practitioners (THPs) to provide data on threats and strategies for conserving medicinal plants. A total number of 300 sample plots of 30 x 30 m were selected to assess the abundance of medicinal plants in the three study sites. 3 quadrats were nested in each sample plot; 10 x 10 m for trees, 5 x 5 m for shrubs, and 1 x 1 m for herbaceous plant species. The most abundant species in the study area were *Leucas aspera* (30.1%), *Justicia flava* (16.1%), and *Toddalia asiatica* (10.6%). The least abundant were *Ficus thonningii* (0.3%) *Vernonia amygdalina* (0.2%) and *Momordica foetida* (0.1%). Agricultural expansion was the primary threat to medicinal plants in the study region (31.3%) followed by overharvesting (21.9%), firewood and Charcoal making (15.6%), and overgrazing (12.5%). 72% of the THPs made attempts to conserve the medicinal plants while 28% did not make any attempt. The study findings will inform sustainable use and support policy formulation for the conservation of these important natural resources.

Keywords: Medicinal plants; Respiratory illnesses; Sustainable management; Threats; Conservation.

Introduction

Respiratory illnesses (RI) are chronic infections that affect the lungs and airways, resulting in a variety of respiratory tract symptoms (WHO, 2022). Asthma, occupational lung illnesses, pulmonary hypertension, and Chronic Obstructive Pulmonary Disease (COPD) are examples of respiratory ailments (Yeh and Horwitz, 2017). Respiratory illnesses cause more than 8 million deaths annually (WHO, 2020). The RI is one of the four primary reasons for morbidity and death, with a large financial strain on health care and a negative impact on productivity in industrialized nations (Brennan, 2017). The severity and

incidence of respiratory ailments stand high in both developing and developed nations, and account for up to 38.6% of infectious illnesses in Africa (Agbor and Najib, 2021). There are significant differences in the prevalence of respiratory illnesses among sub-Saharan African nations, ranging from 1.1% to 23.8% (Magitta *et al.*, 2018; Blanco *et al.*, 2019; Woldeamanuel *et al*., 2019; Sana *et al.*, 2020). In Kenya, respiratory illness is the most common reason people seek medical care (NTLD-P, 2019-2023). In all the age groups, the illnesses account for 10% of outpatient care. Respiratory diseases have been reported in Kenya to be the highest disease burden with about 20,613,455 cases (KNBS, 2021).

Medicinal plants are indispensable source of curative as well as preventive therapeutic preparations (Mbuni *et al*., 2020). There are about 422,000 plant species with therapeutic potential worldwide (Lakey and Dorji, 2016). In addition, many regions of the world commonly use herbal remedies to treat respiratory ailments (Alamgeer *et al.*, 2018). In Kenya, a diverse plant heritage has been utilized to treat a variety of illnesses by many communities (Gachathi, 2007; Kokwaro, 2009; Ochora *et al.*, 2012). Contemporary development of medicines still depends on nature's supply of medicinal plants (Gafna *et al*., 2017).

Forty-one percent (41%) of medicinal plant species are in danger of going extinct globally (IUCN, 2020). For instance, the diversity of medicinal herbs is dwindling due to increased utilization leading to the depletion of about 20% of wild plant resources (Bentley, 2010). Extinction of medicinal plants resulting from increased land use changes negatively impacts the diversity and abundance of these resources (Agbodeka *et al.*, 2016; Amujoyegbe *et al.*, 2016; Youmsi *et al.*, 2017; Dogor *et al.*, 2018). Other significant hazards to medicinal plant resources include; unregulated commerce (Mutwiwa, 2018), destructive harvesting practices (Semenya and Maroyi, 2018), and indiscriminate collection (Phondani *et al*., 2016). In Kenya, unethical harvesting methods and the degradation of plant ecosystems, have led to a keen drop in the availability of medicinal plants (Fabricant and Farnsworth, 2001). Moreover, the conservation of medicinal species has received little attention in research. In Migori County, there is inadequate data on the conservation of medicinal plants. This is against the backdrop of increased extraction, population increase, and land use changes. This study aimed to assess the abundance and threats to medicinal plants utilized in managing respiratory ailments in Migori County. The findings will help in policy formulation and sustainable conservation of these important natural resources.

Materials and Methods

Study area

The study was carried out in three sub-counties namely Kuria East, Kuria West and Suna East in Migori County, Kenya. Migori County lies between latitudes 1° 4′ 7.98″ South and 1° 40' South whereas longitudes are 34° 28′ 14.19″ East. The altitude ranges between 1140 to 4625 meters above sea level. The County is bordered to the East by Kisii and Narok Counties, to the South by the Republic of Tanzania, and to the North by Homa Bay County (Figure 1). To the west, it abuts Lake Victoria. The climate of the County is inland equatorial influenced by Lake Victoria. Annual rainfall ranges from 1800mm to 2,000mm. The average temperature ranges from 24° C to 31° C. Two rainy seasons are experienced in the County, short rains between September and November and long rains between March and May. Large parts of Kuria East and Kuria West are covered with 'relatively acid' parent rock and granite, with the rest being covered by Nyanzian and Bukoban rocks (Migori County Annual Development Plan, 2023). Kuja, Migori, and Riana are the major rivers in the County, which originate from the highlands of neighboring Kisii and Narok counties and drain in Lake Victoria. The County's total forest cover is way below national forest cover at 0.03% with 11.4385 km^2 being a gazetted forest reserve and 45.53 km^2 of non-gazetted forest (Migori County Annual Development Plan, 2023). The population of Kuria West, Suna East, and Kuria East is 208,513, 122,674, and 96,872 respectively (KNBS, 2019). The County's topography is made up of undulating hills, with a few sections of flat territory. It is a multiethnic county with dominant local communities being Kuria and Luo-speaking. Other communities in the county are the Somali, Maasai, Luhya, Kikuyu and Kisii. Agriculture, livestock production, and small-scale mining are the leading economic activities. Maize, beans, cassava, vegetables and sweet potatoes are among the major food crops cultivated

in the County. Sugarcane, rice and tobacco are the major cash crops.

Sampling design

The Kuria East, Kuria West and Suna East sub-counties were purposively selected given that herbal medicine made from species of medicinal plants was widely utilized in the three study sites. Purposive sampling was used since it chooses relevant and typical characteristics like vegetation types or vegetation areas. A pre-determined list provided by the chairman of the Herbalists Society of Kenya was used to purposively sample 32 Traditional Health Practitioners (THPs) within Migori County. Semi-structured questionnaires were used to collect data from the THPs. The questionnaires collected data on the therapeutic herbs utilized by THPs as well as threats to and conservation measures for medicinal plants. THPs and a taxonomist accompanied researchers during the survey to identity and classify the medicinal plants mentioned by the respondents. Each specimen was identified and documented in the field using morphological features like flower structure and leaf form, arrangement and venation.

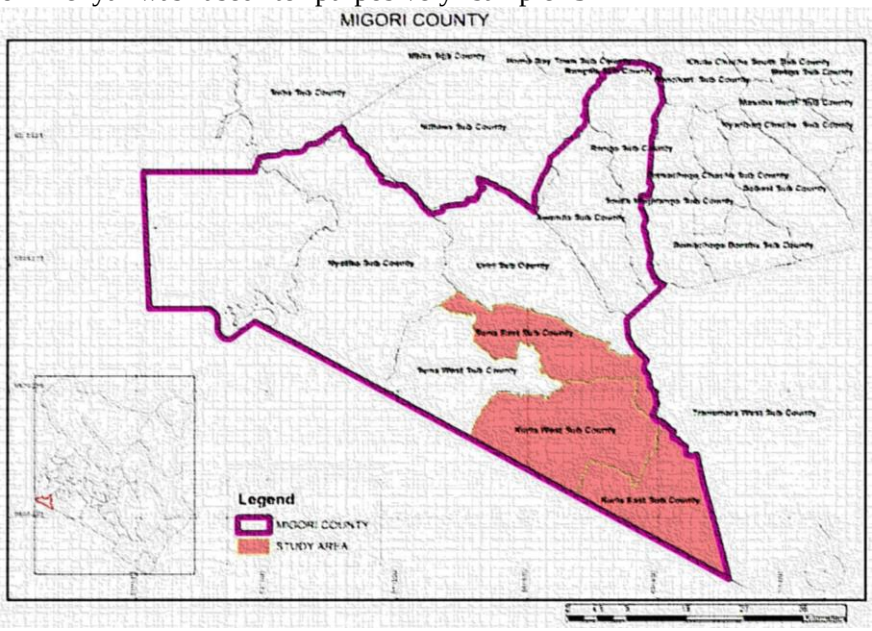

Figure 1: Map of Migori County showing the study areas. Sources: Esri, HERE, Garmin, Intermap, Increment P Corp., GEBCO, USGS, FAO., NPS, NRCAN, GeoBase, IGN, Kadaster NL,Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributers and the GIS use community.

Assessment of medicinal plants abundance

The abundance of medicinal plants was obtained by the use of the transect-quadrat approach. In each study site, five transects were laid in forested areas and farmed areas. 500-meter line transects placed 200 meters apart were used. Along the transects, plots of 30 x 30 m each were delineated at an interval of 20 meters. A randomized design was used to lay quadrats of 10 x 10 m, 5 x 5 m, and 1 x 1 m to assess trees, shrubs, and herbaceous plant species respectively. A total of 15 transects and 150 nested quadrats were used in the survey. A comprehensive survey was conducted in each quadrat, and the abundance of species of medicinal value was recorded.

Threats to medicinal plants

Threats to medicinal plants were established during field surveys. In addition, the THPs provided data in the questionnaires administered. The THPs also elaborated on the methods they employed to conserve medicinal plant species in the region.

Data analysis

The abundance of the species was determined using Mahajan and Fatima, (2017) formula. Data from the questionnaires was coded, entered into an excel sheet and analyzed using the Statistical Package for the Social Science (SPSS) software version 22. Data was summarized using descriptive statistics (percentage and frequency).

Ethical considerations

The Kenya Medical Research Institute's (KEMRI) Scientific Ethics Review Unit (SERU) and Kenya Ref (KEMRI/SERU/CTMDR/093/4178) granted ethical approval for this work.

All procedures were carried out in compliance with applicable rules and regulations. Before conducting the interviews, the study informants/respondents were fully informed of the study, and verbal agreement was acquired.

Results and Discussion

Identification and sampling of the Herbalists

A total of thirty-two THPs (15 women and 17 men) were interviewed. Fifty percent (n=16) of the THPs came from Kuria East, 35% (n=11) from Suna East, and 16% (n=5) from Kuria West. The time periods through which THPs have been practicing range from 3 years to 50 years. The average duration of service for THPs was 14.2 years (Table 1). Fifty three percent (53%) of THPs had primary education, 25% had secondary education, 15.6% had no formal education and 3.1% each had university and college education. It was established that the practice of herbalism was passed down through generations.

Table 1. Demographic information of THPs.

Demography	Category	Frequency (n = 32)	Percentage
Gender	Male	17	53.1
	Female	15	46.9
Ages	Below 25 years	0	0.0
	25 - 30	1	3.1
	31 - 35	1	3.1
	36 -40	2	6.3
	41 - 45	4	12.5
	46 -50	5	15.6
	Above 50 years	19	59.4
Education level	Primary	17	53.1
	Secondary	8	25.0
	College	1	3.1
	University	1	3.1
	No formal education	5	15.6
Source of livelihood	Farming	20	62.5
	Herb seller	7	21.9
	Business	5	15.7
Duration of practice (Years)	0 - 5	9	28.1
	6 - 10	7	21.9
	11 - 15	6	18.8
	16 - 20	4	12.5
	21 - 25	1	3.1
	Above 25	5	15.6

Abundance of selected medicinal plants

In this study, 22 medicinal plant species (Table 2) were selected for further assessment of their abundance. Ninety-seven percent (97%) of medicinal plants occurred naturally in the wild while 3% were found in cultivated areas. The predominant status of the plant was shrubs followed by trees and herbs at 38.3%, 33.9% and 21.4% respectively. *Leucas aspera* (Family Lamiaceae) and *Justicia flava* (Family Acanthaceae) had the highest abundance in all the three sites sampled. In Kuria East, the abundance of *Leucas aspera* and *Justicia flava* was 29.1% and 19.4% respectively, *Sesbania sesban* (9.7%), *Microglossa pyrifolia* (9.7%) and *Toddalia asiatica* (9.7%) were found to be moderately dominant. The least abundant species was *Vernonia amygdalina* at 0.1%. In Kuria West, the abundance of *Leucas aspera* was 20.1% followed by *Justicia flava* at 19.1%. The least abundant species were, *Phoenix reclinate*, *Vernonia amygdalina*, and *Erythrina abyssinica* at 0.4%,

0.4% and 0.2% respectively. In Suna East, *Leucas aspera* had an abundance of 41.1% followed by *Justicia flava* at 10.3% and *Corchorus trilocularis* at 10.3%. The least abundant plant species was *Phoenix reclinate* at 0.2%. *Ficus thonningii*, *Momordica foetida* and *Vernonia amygdalina* were absent in Suna East (Table 2).

Leucas aspera which had the highest abundance in the three sites was utilized to manage cough, chest pains, and breathing problems by THPs who were privy to its existence. Its abundance could be attributed to the fact that it is a widespread weed and an annual herb (Prajapati *et al*., 2010). The least abundant species was *Momordica foetida*, which belongs to Cucurbitaceae family. It was highly utilized by THPs in the management of pneumonia. This species was absent in Kuria West and Suna East. This can be attributed to its high demand by the THPs who extract its roots thus reducing its growth and abundance. The destructive mode of harvesting and deforestation hampers its survival (Fabricant and Farnsworth, 2001). Furthermore, land use change to settlement or agriculture limits the survival of this wild climbing herb.

It was observed that species with lower use values were more common in the field than those with higher use values. Since medicinal plants with high use value are over-extracted, their abundance in the wild decreases as those that are less preferred take dominance. Mid altitudes also foster a diversity of plant species because they produce a range of temperature conditions providing diverse niches for species to exploit. The abundance of the selected plants decreased from Kuria East to Suna East. This is a result of a decrease in altitude coupled with anthropogenic disturbances. In Suna East, for example, more land has been cleared to pave the way for urbanization and settlement given that it hosts the County headquarters and also has a relatively dense population.

Table 2. Abundance of medicinal plants in the study area.

S/N.	Species	Family	Kuria East Frequency of individual species (F)	Abundance (%)	Kuria West Frequency of individual species (F)	Abundance (%)	Suna East Frequency of individual species (F)	Abundance (%)
1	*Ageratum conyzoides*	Asteraceae	5	0.5	5	1.0	2	0.4
2	*Canthium gueinzii*	Rubiaceae	30	2.9	8	1.6	11	2.3
3	*Corchorus trilocularis*	Malvaceae	9	0.9	15	3.0	50	10.3
4	*Ekebergia capensis*	Meliaceae	10	1.0	14	2.8	5	1.0
5	*Erythrina abyssinica*	Fabaceae	2	0.2	1	0.2	10	2.1
6	*Ficus thonningii*	Moraceae	2	0.2	4	0.8	0	0.0
7	*Fuerstia africana*	Lamiaceae	10	1.0	3	0.6	2	0.5
8	*Helichrysum cymosum*	Asteraceae	40	3.9	10	2.0	3	0.6
9	*Justicia flava*	Acanthaceae	200	19.4	95	19.1	50	10.3
10	*Kigelia africana*	Bignoniaceae	50	4.8	20	4.0	7	1.4
11	*Leucas aspera*	Lamiaceae	300	29.1	100	20.1	200	41.1
12	*Leucas calostachys*	Lamiaceae	22	2.1	10	2.0	40	8.2
13	*Lippia javanica*	Verbenaceae	20	1.9	7	1.4	3	0.6
14	*Microglossa pyrifolia*	Asteraceae	100	9.7	80	16.1	10	2.1
15	*Momordica foetida*	Cucurbitaceae	2	0.2	0	0.0	0	0.0
16	*Phoenix reclinate*	Arecaceae	5	0.5	2	0.4	1	0.2
17	*Psidium guajava*	Myrtaceae	8	0.8	5	1.0	30	6.2
18	*Rhus vulgaris*	Anacardiaceae	5	0.5	3	0.6	1	0.2
19	*Sesbania sesban*	Fabaceae	100	9.7	40	8.0	20	4.1
20	*Toddalia asiatica*	Rutaceae	100	9.7	70	14.1	40	8.2
21	*Vernonia amygdalina*	Asteraceae	1	0.1	2	0.4	0	0.0
22	*Warburgia ugandensis*	Canellaceae	11	1.1	4	0.8	2	0.4

Table 3. Symptoms treated by medicinal plants

	Botanical Name	Family Name	Symptoms Treated
1	*Ageratum conyzoides*	Asteraceae	Fever, flu
2	*Canthium gueinzii*	Rubiaceae	Cough, Breathing difficulties
3	*Corchorus trilocularis*	Malvaceae	Pneumonia, blocked nose
4	*Ekebergia capensis*	Meliaceae	Breathing difficulties
5	*Erythrina abyssinica*	Fabaceae	Cough
6	*Ficus thonningii*	Moraceae	Pneumonia, chest pains
7	*Fuerstia africana*	Lamiaceae	Breathing difficulties, fever, flu
8	*Helichrysum cymosum*	Asteraceae	Chest pains, cough
9	*Justicia flava*	Acanthaceae	Breathing difficulties
10	*Kigelia africana*	Bignoniaceae	Flu, pneumonia, breathing difficulties
11	*Leucas aspera*	Lamiaceae	Cough, fever, chest pains, pneumonia, breathing difficulties
12	*Leucas calostachys*	Lamiaceae	Flu
13	*Lippia javanica*	Verbenaceae	Fever
14	*Microglossa pyrifolia*	Asteraceae	Cough
15	*Momordica foetida*	Cucurbitaceae	Pneumonia
16	*Phoenix reclinate*	Arecaceae	Sore throat
17	*Psidium guajava*	Myrtaceae	Flu, cough
18	*Rhus vulgaris*	Anacardiaceae	Chest pains, sore throat
19	*Sesbania sesban*	Fabaceae	Fever, flu, breathing difficulties
20	*Toddalia asiatica*	Rutaceae	Blocked nose, breathing difficulties, cough
21	*Vernonia amygdalina*	Asteraceae	Breathing difficulties
22	*Warburgia ugandensis*	Canellaceae	Pneumonia, cough, breathing difficulties

Threats to medicinal plant species in Migori County

Based on the information provided by the respondents, the prospective medicinal plants in the study area faces numerous threats/risks (Figure 2). Agricultural expansion (31.3%) was the primary threat followed by overharvesting (21.9%), firewood and charcoal production (15.6%), and overgrazing (12.5%). Some respondents (23%) alluded that additional threats within the study region were a consequence of the introduction of exotic trees, climate change, and invasive species (6.3%). These threats are fueled by rising demand for herbal products that strain available medicinal species in the wild (Bentley, 2010). Further, communities in developing nations still rely heavily on alternative medicines for their healthcare demand because they are deemed accessible and cost-effective (Agbor and Najib, 2021; Ekor, 2014). Land use changes for agricultural, settlement, and urban development drive vegetation cover and species loss the world over (Epstein *et al*., 2003). According to the Migori County Annual Development Plan (2023-2027), firewood as well as charcoal were the primary sources of energy for the urban and rural dwellers. This puts pressure and increases demand for selected tree species to be used for charcoal burning and as firewood thus reducing their abundances in the wild.

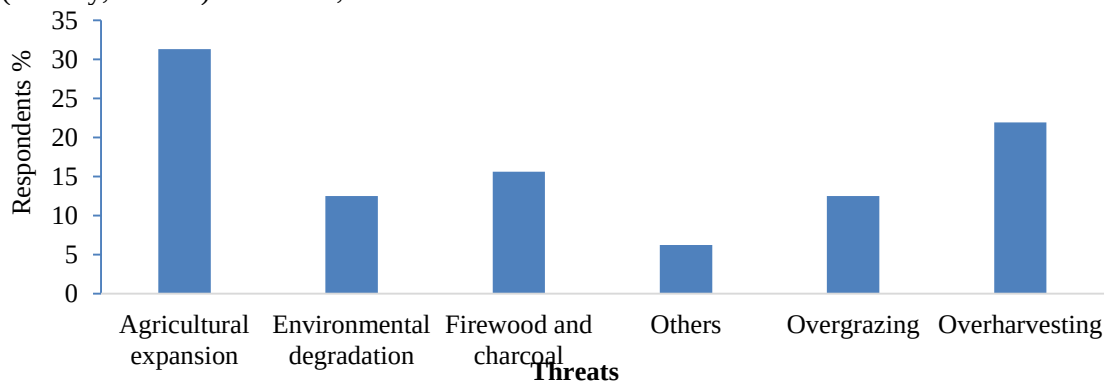

Figure 2: Threats to medicinal plants in Migori County

Overharvesting (21.9%) was a major threat to some taxa namely; *Toddalia asiatica* and *Rubia cordifolia*. *Momordica foetida* a climber plant have been uprooted by the THPs and this led to the decline in its numbers. On the other hand, *Toddalia asiatica* after its roots are harvested. This corroborates with the findings of Phondani *et al*., (2016) that due primarily to overharvesting and uncontrolled collection from their natural habitats, wild medicinal herbs have been nearly depleted. In Uganda, it was noted that the majority of medicinal plants are collected from the wild by abrasive techniques like uprooting and debarking, which endanger the plants' existence (Tugume and Nyakoojo, 2019). Additionally, Semenya and Maroyi, (2018) in their study also found out that unacceptable collection frequencies and ring-barking of stem bark have a consequential negative effect on the diversity of medicinal plants.

Erythrina abyssinica, Kigelia africana, Euphorbia candelabrum and *Markhamia lutea* were affected by agricultural expansion. These tree species were felled to provide room for cultivation, used as firewood or charcoal production, and for construction materials (Anyinam, 1995; Giday, *et al*., 2003; Alves and Rosa, 2007). The multiple uses of medicinal tree species resulted in an increased rate of removal and low abundance in their natural ranges. Land use change to agriculture has led to habitat loss of medicinal plants as well as reduced biodiversity in the study region. A study in Kenya by Hamilton, (2008) showed that habitat destruction raised the possibility of medicinal plants to become extinct. Furthermore, the loss of medicinal plant diversity has been connected to changes in land-use practices in many parts of Kenya (Cebrián-Piqueras *et al.,* 2017; Siebert *et al.,* 2021).

Warburgia ugandensis was majorly threatened by firewood and charcoal production (15.6%). As mentioned by the THPs, locals in Kuria West found *Warburgia ugandensis* a good charcoal producer and hence a sharp decline in its abundance as it is exploited to meet the energy needs of a rapidly urbanizing population. This was also alluded to by Guswarni *et al*., (2020).

Overgrazing was reported to impact on the abundance of *Tithonia diversifolia* and *Clerodendrum myricoides* in the free-access wild lands. This has led to a decrease in the availability of these species in the region. The reduction in their abundance was a result of these species being mostly preferred by grazing animals. Grazing in the region was majorly communal. Consequently, free-range areas are overgrazed. This study shows that overgrazing is a threat that significantly impacts the abundance of medicinal plants. This is in agreement with earlier findings by Wangchuk and Olsen (2011) who alluded that the effects of extensive overgrazing may result in further habitat loss and a decrease in the natural populations of valuable medicinal plants. Biketi, (2001) also pointed out in his study that overgrazing has led to a shortage of medicinal plants.

Carrisa edulis and *Leucas calostachys* were mentioned as species affected by the presence of exotic trees such as *Eucalyptus grandis*. In the study area, the local people grow tree species for diverse reasons such as the provision of construction poles, posts, and firewood for sale, *Eucalyptus* species being most preferred. However, the presence of *Eucalyptus* species leads to acidification of the soils which does not permit survival of indigenous plants including medicinal species. Very little or no understory was found in eucalyptus plantations.

Conservation of medicinal plants

The sustainability of medicinal plants is guaranteed when a population that exploits the resources are conscious of its future availability as seen in this study. The majority of the THPs (72%, n=23) indicated that they made attempts to conserve medicinal plants, whereas only 9 (28%) did not make any conservation attempt. Additionally, half of the respondents (49.8%) mentioned that the cultural and spiritual practices of the populace have contributed to the preservation of medicinal plants. For instance, it was perceived that therapeutic plants would be potent if harvested as well as administered only by the THPs. The primary justification for the conservation of medicinal plants was the guarantee of the preservation and management of the medicinal plants. The inability of the local inhabitants to identify medicinal plants, for example, played a major role in protecting the species from overuse as reported by a section of the THPs (5.4%). Some THPs (25%) opted to grow fast-maturing indigenous trees like *Croton megalocarpus* and *Acacia abyssinica* for their domestic use instead of felling trees. This has helped conserve some specific species like *W. ugandensis* which was highly targeted for charcoal production in Kuria East.

In the protected areas such as Otacho forest in Suna East, THPs were allowed to harvest

specific medicinal plants at controlled levels to allow them to regenerate. This helped conserve medicinal plants since the local herbalists could not overharvest. *In-situ* type of conservation was also exercised whereby threatened medicinal plant species such as *Vernonia amygdalina* and *Rhus vulgaris* were conserved in their original habitat. This promoted the adaptation process and continued evolution of the species under changing environmental conditions. Consequently, the relationship between resource conservation and sustainable usage was strengthened.

The THPs further pointed out that on-farm cultivation of medicinal plants such *Centella asiatica* and *Schkuhria pinnata* (herbs) is easy and trees offer long-term use when available on the farm. Whole harvesting of the plants was not permitted for climbers and succulents, since it would prevent the next user from harvesting and using the plant. THPs who contravened this rule were subjected to a monetary fine. To prevent extirpation and local declines of plant species whose roots were used for making herbal medicines like *Toddalia asiatica, Momordica foetida* and *Microglossa pyrifolia*, THPs harvested few roots thus leaving some behind to help the plant regrow. This was practiced by 3.3% of the respondents pointing out that a large proportion of THPs were not conscious of the survival of the species they harvested. This calls for increased awareness and sensitization on sustainable harvesting practices among the THPs in Migori County. The main goal of conservation is to promote sustainable utilization of biological resources by practices that limit the depletion of the world's reservoir of genetic diversity. The THPs in the study area practiced on-farm cultivation to avoid depleting medicinal plant species. This agrees with the findings by Feyssa *et al*., (2015) who pointed out that people in Southwestern Ethiopia conserve medicinal plant species in farm fields so as not to lose the valuable resource. A study in Pakistan by Alam *et al*., (2011) also showed that cultivation of medical plants has steadily increased the number of therapeutic plant species. *In-situ* type of conservation has also been exercised whereby vulnerable medicinal plant species are conserved in their original habitat.

Conclusion

A total of 22 species were found to be of importance in managing respiratory illnesses in Migori County. *Leucas aspera, Toddalia asiatica* and *Justicia flava* were the most abundant species across the three study sites while *Vernonia amygdalina* and *Momordica foetida* were the least abundant. The study established that agricultural expansion, overharvesting and firewood/charcoal making were the main threats to the survival of medicinal plant species. The majority of the THPs have put in the effort to conserve medicinal plants through sustainable harvesting and on-farm cultivation. Therefore, there is a need for targeted public awareness and sensitization on the importance of environmental conservation as well as sustainable harvesting of medicinal plants to safeguard their existence for posterity.

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