Traditional use and conservation of medicinal plants among Hehe society in Tanzania

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Research

Abstract

Background: The knowledge and use of medicinal plants are deeply rooted in the socio-cultural heritage of many African tribes. The study investigated the traditional use and conservation of medicinal plants among the Hehe community in Iringa, Tanzania, in response to increasing environmental pressure and demand for herbal remedies.

Methods: The research was conducted in Mufindi and Kilolo districts during July 2022 and May 2023 through social surveys and field visits to document local medicinal plant species and conservation practices employed. Thirty key informants, including traditional healers, village leaders, and elders, were interviewed alongside twelve focus group discussions with youth, men, and women. Field visits, aided by a botanist, facilitated the identification of species mentioned during the surveys.

Results: The study recorded 152 medicinal plant species across 61 families. Asteraceae and Fabaceae were the most represented families (16 species each), followed by Rubiaceae (12 species). An analysis of the IUCN Red List showed that most species were categorised as "Least Concern." However, *Prunus africana* was classified as "Vulnerable," and *Warbugia ugandensis* subsp. ugandensis, though unlisted, was noted as rare and heavily exploited. Leaves were the most used (44%), followed by roots (37%), stem bark (13%), fruits/seeds (3%), tubers (1%), and whole plants (2%). Trees were the most utilised (31%), followed closely by herbs (30%), shrubs (29%), climbers (7%), subshrubs (2%), and parasitic plants (1%). Traditional conservation practices employed were the use of sacred groves, spiritually guided harvesting, selective harvesting, and plant domestication.

Conclusions: The findings underscore the rich ethnobotanical knowledge of the Hehe people and highlight the need for sustainable conservation of medicinal plant resources.

Keywords: Traditional conservation, sacred groves, ethnobotany, *Prunus africana*, *Warbugia ugandensis*

Background

Most plants produce multiple bioactive compounds to protect themselves from predators and other harmful organisms (Bernhoft 2010; Jamiołkowska 2020). These bioactive compounds also have potential medicinal properties for human health, classifying these plants as medicinal plants (El Aboui *et al.* 2025). Within local communities, particularly in rural areas, medicinal plants have been relied upon for generations to treat various diseases and are deeply rooted in different cultures (Batool *et al.* 2025). The knowledge, practices and beliefs associated with the use of medicinal plants are considered a significant socio-cultural heritage in Africa, with a history that spans centuries (Elujoba *et al*. 2005). In Africa, over 80% of the population relies on medicinal plants as their primary healthcare, whereas more than 25% of prescribed drugs in developed countries are derived from various plant species (Hamilton 2004; Chen et al. 2016). It has been reported that more than 90% of medicinal plants are harvested from the wild (Balunas & Kinghorn 2005; Addisie *et al*. 2012). Given the increasing conversion of forests and other natural habitats into agricultural land and for other economic purposes, it is crucial to reconsider the long-term consequences and implement appropriate conservation measures.

The unregulated and unsystematic collection of medicinal plant parts by untrained and inexperienced locals has resulted in overexploitation and the potential extinction of certain plant species. According to the IUCN, approximately 13.5% of the world's vascular plants, which correspond to over 40,000 species, are threatened to varying degrees (Gowthami et al. 2021). However, only a fraction of the medicinal plants facing genetic erosion and extinction risks have been included in the IUCN Red List as threatened species, indicating a lack of adequate information on the conservation status of medicinal plants worldwide. Various factors contribute to the loss of medicinal plants, including habitat specificity (broad vs restricted), distribution range (wide vs narrow), population size (large vs small), species diversity (high vs low), growth rate (fast vs slow), and reproductive system (vegetative, generative or both) (Chen *et al*. 2016). A study by Okigbo *et al*. (2008) projected the rate of loss of tropical plant species since the 1990s, which shows that up to 2040, there will be a loss of about 30% of plant species. This is an alarming call for the conservation of medicinal plants to foster their sustainable use.

Three different methods are commonly employed in the conservation of medicinal plants: *in-situ*, *ex-situ*, and good cultivation practices (Chen *et al*. 2016). However, the choice of conservation methods must be guided by the biological characteristics of each species. This is because the majority of medicinal plants are endemic, and their secondary metabolites, which include their medicinal properties, are influenced by their natural environment (Figueiredo & Grelle 2009). Therefore, any alterations to their natural habitat may impact on the quality and quantity of the bioactive compounds associated with their medicinal properties. Such changes have been documented in various studies, including Pant *et al.* (2021). *In-situ* conservation may therefore be potentially effective as it safeguards indigenous plants in their natural areas of occurrence and helps maintain the plant community network (Ma *et al*. 2012). It also contributes to the protection of diverse species by focusing on ecosystem conservation rather than the conservation of individual species. On the other hand, although *ex-situ* conservation facilitates access to potential plant species in different geographical locations (Huang *et al*. 2002), reintroduction and establishment of populations in the wild can be challenging (Braverman 2014). In case the quality and quantity of the bioactive compounds associated with the plant's medicinal properties are not affected, cultivation practices offer the advantage of reducing overdependence on wild resources and promoting their recovery while also increasing accessibility (Wong *et al.* 2014).

The reliance on medicinal plants, particularly in Tanzanian rural communities, has been steadily increasing due to the cost of modern medical services, which are often unaffordable for the majority (Assan *et al*. 2009). Moreover, traditional healers are often the only accessible medical practitioners within a reasonable distance in these rural areas, compared to medical doctors (Chi 1994; Amzat *et al*. 2014). While rural communities possess knowledge of medicinal plant usage, traditional healers employ local techniques to process plant parts, such as leaves, roots, or barks, into powder for treating various ailments, which they sell at affordable prices. The Hehe tribe in Iringa is particularly renowned for its use of medicinal plants in the treatment of various health disorders. Over the years, the region has been recognised for its diverse array of plant species with medicinal properties (Augustino & Gillah 2005; Shangali *et al.* 2008; Iwu 2014). With the growing market for traditional medicines and the emergence of several health disorders, including COVID-19, the study aimed to explore the IUCN conservation status of the medicinal plants used in the region, the dominant growth form and most frequently used plant parts, and the traditional conservation practices employed. This was useful to answer the study hypothesis that there is a deterioration of medicinal plants used by the Hehe community due to overharvesting and poor conservation.

Materials and Methods

Study area

The ethnobotanical study was conducted in Iringa Region, covering two districts of Mufindi and Kilolo (Fig. 1), which were purposively selected based on their geographical locations and the availability of traditional healers and users of medicinal plants. Kilolo District has a total area of 7,882 km2 and lies between 7.8835° S and 36.0893° E. It is crossed by the Udzungwa Mountains with elevations ranging from 900 to 2700m above sea level (Jalango *et al*. 2019). The district experiences a temperate climate, with rainfall ranging between 600mm in lowland areas and 1,600mm in mountainous areas (Kassian *et al.* 2017), and temperatures between 8°C and 27°C. More than half of Kilolo is forested, where tropical rainforest, montane forest and miombo woodlands are dominant vegetations (Msalilwa 2013). Over 80% of the population relies on agriculture as a major economic activity. Mufindi District, on the other hand, lies between 8.6441° S, 35.1269° E with an elevation ranging from 1500 to 2,200m above sea level. Mean annual rainfall ranges from 960mm to 1400mm, with an average annual temperature between 17 °C and 20 °C, but the coolest period is from June to August, when temperatures can drop to about 5 °C (Jalango *et al*. 2019). The main economic activity is also agriculture for both food and cash crops such as tea, sunflower and pyrethrum (Kangalawe 2012). Generally, Iringa Region is a potential site for ethnobotany studies due to its rich ecological diversity, cultural heritage and ongoing reliance on traditional medicine from plants.

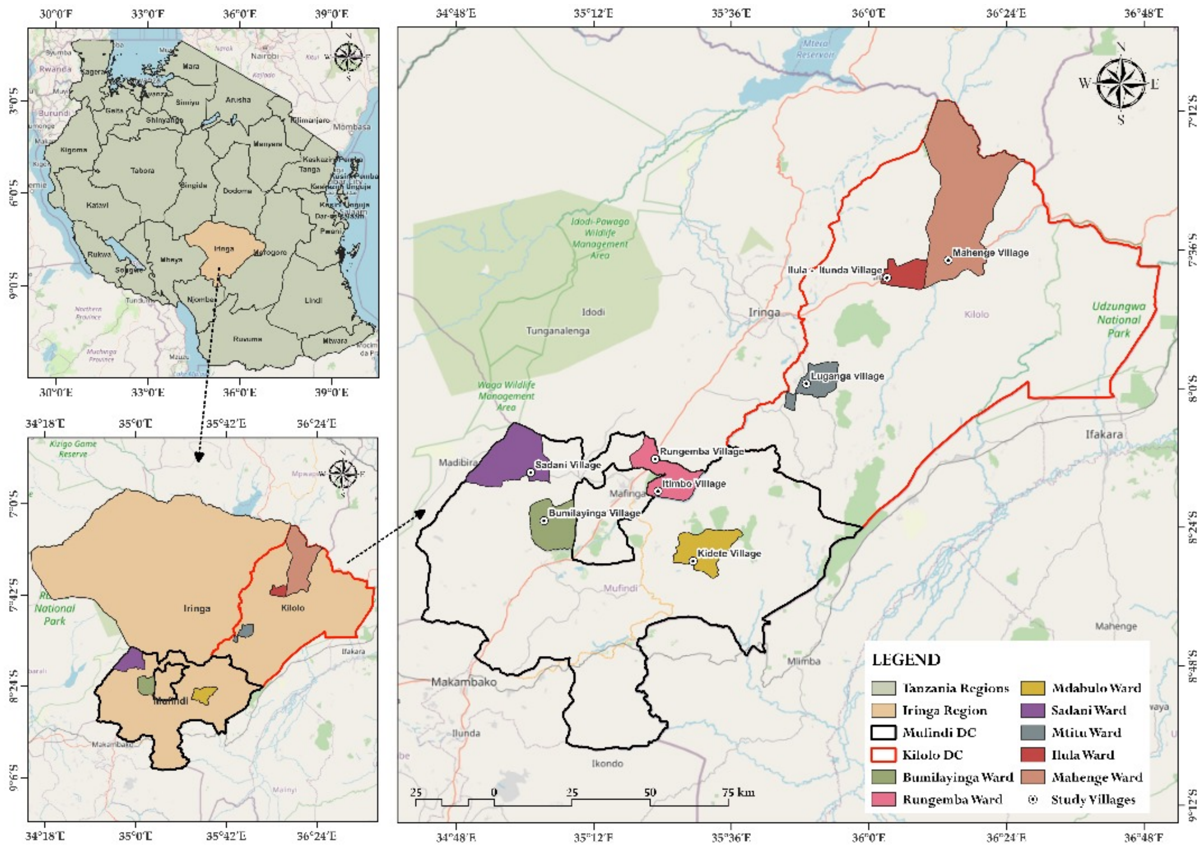

Figure 1. Map of Iringa Region, Tanzania, showing the study area

Sample size and sampling procedure

The study employed a multiple-stage sampling procedure to select the research sites. In the first stage, Iringa Region and two specific districts (Kilolo and Mufundi) were intentionally chosen. Subsequently, in the second stage, two wards were strategically selected from each district, resulting in a total of four wards. The third stage involved a random selection of two villages from each ward, resulting in a total of eight villages. Moving on to the fourth stage, a purposive sampling technique was used to select key informants who were traditional healers, village leaders, and clan elders. A total of 30 key informants from the two districts were interviewed, given their significant role in the utilization of medicinal plants. Furthermore, comprehensive information regarding the use of medicinal plants was gathered through 24 focus group discussions that comprised men, women and youth separately, with each discussion consisting of a minimum of three and a maximum of eight participants.

Data collection

Key informant interviews paired with focus group discussions and field surveys were the primary methods employed for data collection and were conducted in July 2022 and May 2023. Within each district, key informants, including village leaders, traditional healers, clan leaders, and elders, both male and female, were interviewed using a prepared checklist regarding their knowledge and practices in the utilization of medicinal plants. In addition, three distinct focus group discussions were carried out in each village, involving men, women, and youth and each group was treated differently to ensure freedom of expression. The aim of focusing on the three different groups was to explore the details of the use of medicinal plants based on their social roles and life experiences. Throughout the interviews and group discussions, participants shared their personal experiences with medicinal plants, specifying the parts of the plants used, traditional conservation techniques and availability of such plants in the region. Following the discussions and interviews, a field survey of medicinal plants was conducted with the assistance of an experienced botanist from the University of Dar es Salaam, traditional healers, village leaders, and other influential individuals who helped to identify the plants. The identification was done in the field except for a few species for which field identification was not possible; thus, herbarium specimens were prepared for further identification in the botany laboratory at the University of Dar es Salaam, where the specimens are also stored. The scientific names of the species were further confirmed using the Plants of the World Online (POWO), an online taxonomic database published by the Royal Botanic Gardens, Kew, to ensure the use of first published species names according to the principles of International Code of Nomenclature for algae, fungi, and plants (ICN), previously called the International Code of Botanical Nomenclature (ICBN). A comprehensive list of medicinal plants mentioned by the respondents, as well as those observed in the field, was compiled for each district.

Data Analysis

The data were cleaned and sorted by family, plant part used, growth form, and IUCN categories using the online IUCN database. The data were then analysed using SPSS (ver. 22) software. The qualitative data, including the traditional conservation techniques employed, were thematically analysed.

Results

IUCN conservation status of the surveyed medicinal plants

The findings show that the majority of the indigenous plants used as medicinal plants that were identified in the field from Mufindi and Kilolo districts are under the 'Least Concern' category of IUCN, except for *Prunus africana* (Hook.f.) Kalkman, which is Vulnerable. *Prunus africana* is an endemic species to Africa, growing up to more than 40m long with a diameter of 1m (Dawson *et al*. 2000). It is more dominant in mountainous or highland forest areas. It is the only species of *Prunus* that is endemic to Africa (Dawson *et al*. 2000; Stewart 2003). The bark of the tree is a potential product in the manufacture of drugs for the treatment of prostate cancer (Ochwang'i *et al*. 2014; Komakech *et al.* 2017) and asthma (Karani *et al*. 2013). Due to the pharmacological properties of the species, it is reported (Dawson *et al*. 2000) to be highly overharvested in many areas, including the sites visited in this study (Fig. 2).

Prunus africana belongs to the family Rosaceae. Other plant species identified in this family include *Alchemilla kiwuensis* Engl., *Rubus pinnatus* Willd. (Table 1). Although *P. africana* is highly recognised for its use in the treatment of male potency in the area, *A. kiwuensis* was reported to treat toothache, while *R. pinnatus* is used for the treatment of gonorrhoea, syphilis, and sexually transmitted diseases (STDs) using the roots and leaves. However, literature reports suggest additional uses of *A. kiwuensis* in the treatment of epilepsy (Ngoupaye *et al*. 2021) and its anti-inflammatory activities (Kamtchueng *et al*. 2017). *Rubus* species are also reported to have anti-cancer chemical compounds (George & Abrahamse 2021). This highlights additional medicinal values of these plants that have yet to be widely documented.

According to Jaenicke *et al.* (2000), *P. africana* seeds have intermediate characteristics, which limit their *ex-situ* seed conservation for extended periods. However, short-term storage (e.g., for a season) is relatively possible when the mature seed is depulped immediately after harvest and stored at 50°C without drying. Various measures have been implemented to ensure its conservation, including strict regulations for trading *P. africana* products under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, Appendix II). *Prunus Africana* is also listed in the Tree Conservation Database of the World Conservation Monitoring Centre (WCMC) and identified as a top-priority species for conservation (FAO 1997).

In addition to *P. africana*, *W. ugandensis* subsp. ugandensis was also observed to be very rare in the study sites and highly overharvested (Fig. 3). *Warbugia ugandensis* belongs to the family Canellaceae and is the only species identified in this family (Table 1). It is one of the most commonly used plants in the area for the treatment of male impotence using the bark. Although the plant is not yet listed under the IUCN category of threatened species, precautions and conservation measures for this plant are crucial for future generations, considering its medicinal potential. *Warbugia ugandensis* is one of the most frequently reported medicinal plants with antibacterial and antifungal activities (Olila & Opuda-Asibo 2001; Husen 2013; Okello & Kang 2021) and is used in the treatment of asthma (Karani *et al.* 2013).

Figure 2. *Prunus africana* utilised for medicinal purposes in Kilolo district, Iringa, Tanzania. Source: Field photo by Onesmo Nyinondi

Figure 3. An over-harvested roots and barks of *Warbugia ugandensis* subsp. ugandensis for medicinal purposes in Mufindi district, Iringa, Tanzania. Source: Field photo by Onesmo Nyinondi

Most used plant parts and growth form of the surveyed medicinal plants, and implications for conservation

The study found that the most used plant parts for the treatment of various ailments in the study areas were leaves and roots, followed by stem bark (Fig. 4). This finding aligns with other studies that report roots and leaves as the most widely used plant parts in traditional medicine (Awulachew 2021). Although each plant part plays a significant role in its growth, overharvesting of these parts may kill the plant. Trees were the most used growth form, followed by herbs and shrubs (Fig. 5). Other researchers have reported that herbs and shrubs are the most common medicinal plants in the studied area (Addisie *et al*. 2012). This is actually due to differences in the geographical location, hence favouring certain growth forms. Considering the difficulty of growing many tree species due to seed dormancy and other limitations, including time to maturity, strict conservation measures should be implemented to ensure their conservation.

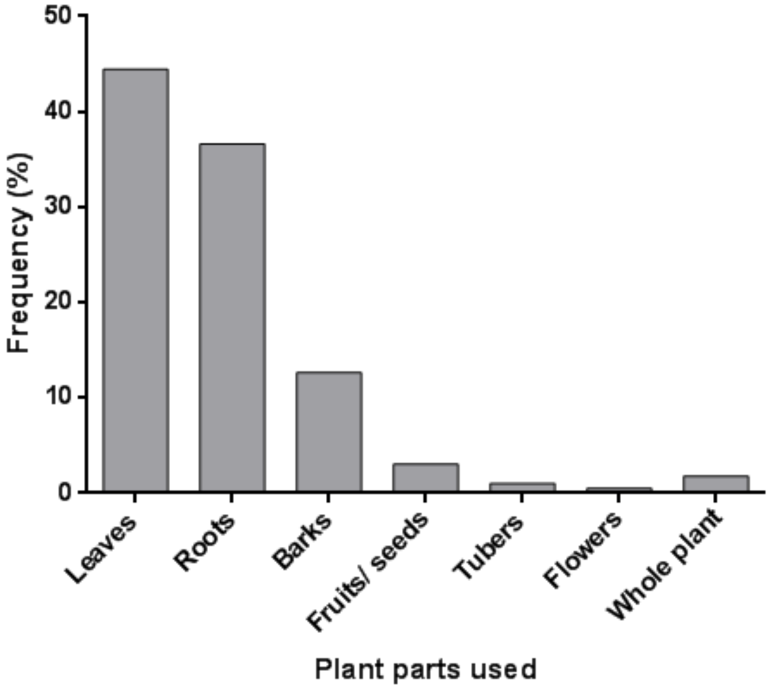

Figure 4. Most used plant parts of the surveyed medicinal plants in Kilolo and Mufindi districts

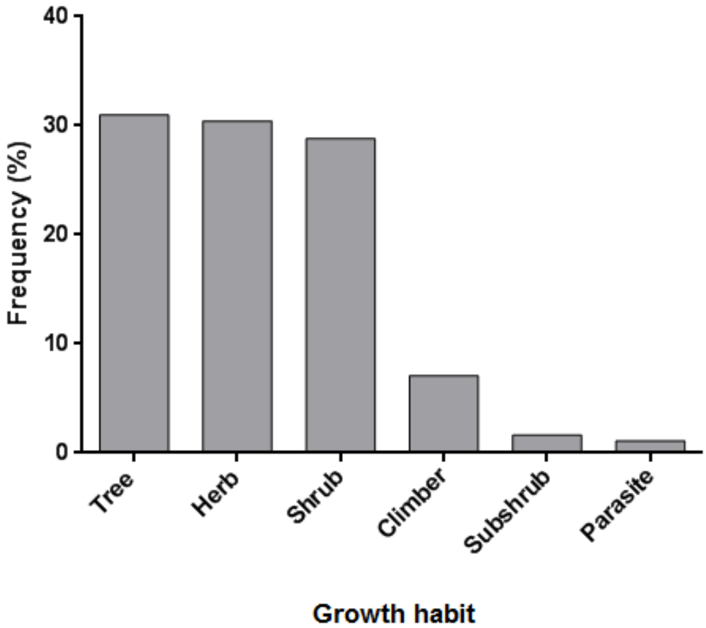

Figure 5. Growth form of the surveyed medicinal plants in Kilolo and Mufindi districts

Species richness of the surveyed medicinal plant families

A total of 61 medicinal plant families consisting of one to several plant species were surveyed. Asteraceae and Fabaceae were the most diverse medicinal plant families, with 16 (10.5% of the identified medicinal plants) species each, followed by Rubiaceae with 12 species. Anacardiaceae and Lamiaceae had seven plant species each. The remaining families had fewer than five species, as summarised in Table 1. The majority (52%) of the families had only one species each, 21% had two species, 13% had three species, and 5% had four species. Only 8% of the plant families had more than four species each. The two families (Asteraceae and Fabaceae) are also widely reported to be the richest families of medicinal plants (Randrianarivony *et al.* 2017; Jamba & Kumar 2018; Uzun & Koca 2020). A total of 152 plant species were identified as medicinal plants (Table 1).

Table 1. Species richness of the surveyed plant families

Family	Species richness	Plant species
Acanthaceae	4	*Hypoestes aristata* (Vahl) Sol. ex Roem. & Schult., *Blepharis affinis* Lindau, *Blepharis maderaspatensis* (L.) B.Heyne ex Roth, *Justicia flava* (Forssk.) Vahl
Amaranthaceae	1	*Achyranthes aspera* L.
Anacardiaceae	6	*Lannea katangensis* Van der Veken, *Mangifera indica* L., *Ozoroa insignis* Delile, *Searsia longipes* (Engl.) Moffett, *Searsia natalensis* (Bernh. ex C. Krauss) F.A.Barkley, *Sclerocarya birrea* (A. Rich.) Hochst
Apocynaceae	3	*Secamone elliptica* R.Br., *Carissa spinarum* L., *Strophanthus eminii* Asch. ex Pax.
Araliaceae	1	*Cussonia spicata* Thunb.
Asparagaceae	4	*Asparagus falcatus* L., *Asparagus setaceus* (Kunth) Jessop, *Asparagus africanus* Lam., *Dracaena steudneri* Engl.
Asphodelaceae	1	*Aloe lateritia* Engl.
Asteraceae	16	*Aspilia pluriseta* Schweinf. ex Engl., *Bidens pilosa* L., *Chrysanthemoides monilifera* (L.) Norl., *Erigeron bonariensis* L., *Echinops giganteus* A. Rich. *Elephantopus scaber* L., *Helichrysum arbuscula* Chiov., *Helichrysum cymosum* (L.) D.Don ex G.Don, *Lopholaena dolichopappa* (O.Hoffm.) S.Moore, *Tagetes minuta* L., *Gymnanthemum amygdalinum* (Delile) Sch.Bip., *Baccharoides anthelmintica* (L.) Moench, *Distephanus divaricatus* (Steetz) H.Rob. & B.Kahn, *Hoffmannanthus abbotianus* (O.Hoffm.) H.Rob., S.C.Keeley & Skvarla, *Pleiotaxis pulcherrima* Steetz, *Linzia glabra* Steetz
Bignoniaceae	1	*Tecomaria capensis* (Thunb.) Spach
Boraginaceae	1	*Trichodesma zeylanicum* (Burm.f.) R.Br.
Canellaceae	1	*Warburgia ugandensis* subsp. ugandensis
Capparaceae	2	*Boscia mossambicensis* Klotzsch, *Capparis spinosa* L.
Caricaceae	1	*Carica papaya* L.
Casuarinaceae	1	*Casuarina cunninghamiana* Miq.
Chrysobalanaceae	1	*Parinari curatellifolia* Planch. ex Benth.
Clusiaceae	1	*Garcinia huillensis* Welw. ex Oliv.
Combretaceae	3	*Combretum longispicatum* (Engl.) Engl. & Diels, *Combretum molle* R.Br. ex G.Don, *Terminalia kaiseriana* F.Hoffm.
Connaraceae	1	*Rourea orientalis* Baill.
Crassulaceae	1	*Kalanchoe crenata* (Andrews) Haw.
Cucurbitaceae	3	*Cucumis anguria* L., *Cucumis dipsaceus* Ehrenb. ex Spach., *Peponium vogelii* (Hook.f.) Engl.
Cupressaceae	2	*Hesperocyparis lusitanica* (Mill.) Bartel, *Cupressus sempervirens* L.
Dennstaedtiaceae	1	*Pteridium aquilinum* (L.) Kuhn
Ebenaceae	2	*Euclea natalensis* A.DC., *Euclea divinorum* Hiern
Euphorbiaceae	2	*Ricinus communis* L., *Croton reflexifolius* Kunth
Fabaceae	16	*Vachellia gerrardi* (Benth.) P.J.H.Hurter, *Vachellia sieberiana* (DC.) Kyal. & Boatwr., *Bobgunnia madagascariensis* (Desv.) J.H.Kirkbr. & Wiersema,

		Cassia abbreviata Oliv, *Delonix elata* (L.) Gamble, *Dichrostachys cinerea* (L.) Wight & Arn., *Erythrina abyssinica* Lam., *Indigofera buchananii* Burtt Davy, *Julbernardia globiflora* (Benth.) Troupin, *Pseudarthria hookeri* Wight & Arn., *Pterocarpus angolensis* DC, *Mimosa pudica* L., *Neorautanenia mitis* (A.Rich.) Verdc., *Rhynchosia hirta* (Andrews) Meikle & Verdc, *Senna singueana* (Delile) Lock, *Grona setigera* (E.Mey.) H.Ohashi & K.Ohashi
Francoaceae	1	*Bersama abyssinica* Fresen.
Hypericaceae	1	*Psorospermum febrifugum* Spach.
Hypoxidaceae	1	*Hypoxis angustifolia* Lam.
Lamiaceae	7	*Ocimum americanum* L., *Tinnea gracilis* Gürke, *Vitex doniana* Sweet, *Vitex madiensis* Oliv., *Vitex strickeri* Vatke & Hildebrandt, *Clerodendrum capitatum* (Willd.) Schumach., *Rotheca myricoides* (Hochst.) Steane & Mabb
Loganiaceae	1	*Strychnos mitis* S.Moore
Loranthaceae	2	*Phragmanthera eminii* (Engl.) Polhill & Wiens, *Plicosepalus meridianus* (Danser) Wiens & Polhill
Lythraceae	1	*Punica granatum* L.
Malvaceae	4	*Hibiscus acetosella* Welw. ex Hiern, *Hibiscus micranthus* L.f., *Grewia pachycalyx* K.Schum., *Grewia goetzeana* K.Schum.
Moraceae	3	*Ficus stuhlmannii* Warb., *Ficus thonningii* Blume, *Ficus sycomorus* L.
Myricaceae	1	*Myrica salicifolia* Hochst. ex A.Rich.
Myrtaceae	4	*Eucalyptus globulus* Labill., *Eucalyptus camaldulensis* Dehnh., *Syzygium guineense* (Willd.) DC., *Eugenia malangensis* (O.Hoffm.) Nied.
Ochnaceae	2	*Brackenridgea zanguebarica* Oliv., *Ochna afzelioides* N.Robson
Olacaceae	1	*Ximenia americana* L
Oleaceae	1	*Schrebera alata* (Hochst.) Welw.
Orobanchaceae	2	*Striga asiatica* (L.) Kuntze, *Cycnium tubulosum* (L.f.) Engl.
Pedaliaceae	2	*Sesamum angustifolium* (Oliv.) Engl., *Sesamothamnus rivae* Engl.
Phyllanthaceae	2	*Uapaca kirkiana* Müll.Arg., *Bridelia micrantha* (Hochst.) Baill.
Pinaceae	1	*Pinus patula* Schiede ex Schltdl. & Cham.
Plantaginaceae	1	*Veronica abyssinica* Fresen.
Polygalaceae	1	*Securidaca longepedunculata* Fresen
Polygonaceae	1	*Rumex usambarensis* (Engl.) Dammer
Primulaceae	3	*Myrsine africana* L., *Maesa lanceolata* Forssk., *Embelia schimperi* Vatke.
Proteaceae	2	*Protea madiensis* Oliv., *Protea petiolaris* (Hiern) Baker & C.H.Wright
Ranunculaceae	1	*Clematis brachiata* Thunb.
Rhizophoraceae	1	*Cassipourea malosana* (Baker) Alston
Rosaceae	3	*Alchemilla kiwuensis* Engl., *Rubus pinnatus* Willd., *Prunus africana* (Hook.f.) Kalkman
Rubiaceae	12	*Afrocanthium burttii* (Bullock) Lantz, *Catunaregam tylorii* (S.Moore) Bridson, *Gardenia ternifolia* Schumach. & Thonn, *Keetia gueinzii* (Sond.) Bridson, *Cordylostigma longifolium* (Klotzsch) Groeninckx & Dessein, *Fadogia triphylla* Baker, *Leptactina platyphylla* (Hiern) Wernham, *Pavetta schumanniana* F.Hoffm. ex K.Schum., *Rothmannia engleriana* (K.Schum.) Keay, *Rubia cordifolia* L., *Rytigynia celastroides* (Baill.) Verdc., *Vangueria madagascariensis* J.F.Gmel.
Rutaceae	3	*Zanthoxylum asiaticum* (L.) Appelhans, Groppo & J. Wen, *Zanthoxylum chalybeum* Engl., *Clausena anisata* (Willd.) Hook.f. ex Benth.
Salicaceae	1	*Flacourtia indica* (Burm.f.) Merr.
Santalaceae	1	*Osyris lanceolata* Hochst. & Steud.
Sapindaceae	1	*Dodonaea viscosa* Jacq.
Solanaceae	2	*Physalis peruviana* L., *Solanum campylacanthum* Hochst. ex A.Rich.
Thelypteridaceae	1	*Thelypteris chaseana* Schelpe
Thymelaeaceae	1	*Lasiosiphon kraussianus* (Meisn.) Meisn.

Verbenaceae	2	*Lippia javanica* (Burm.f.) Spreng, *Lantana viburnoides* (Forssk.) Vahl
Vitaceae	2	*Cissus verticillata* subsp. Verticillata, *Rhoicissus tridentata* (L.f.) Wild & R.B. Drumm.

Traditional beliefs aimed at plant conservation

Traditional use of medicinal plants for sustainable conservation is rooted in the beliefs and practices of the local community and is refined over generations. The study collected detailed information on how the indigenous Hehe society ensures the conservation and sustainable use of medicinal plants, and the following were the major beliefs and practices employed.

Respectful of sacred groves

Sacred groves (SGs) are patches of trees in a forest or woodland ecosystem that are left untouched by the inhabitants and communally protected with high entry restrictions (Kandari *et al.* 2014). These patches may be a community or individual property but are highly protected by everyone due to the strong beliefs and spiritual interconnectedness of such areas. In this study, one SG was found in Rungemba Ward, Mufindi District, which was under the ownership of a traditional healer. The SG consisted of various trees and shrubs, including rare medicinal plants. Entry into the SG was preceded by permission from the spirits believed to exist in the area. Only the owner (the traditional healer who owned the SG) was allowed to ask for such permission and introduce all the team members. This restricted entry by any individual without the presence of the owner and thus increased the conservation of the area. The community highly respected such areas, and no one would dare to go alone, as breaching the rule was associated with unbearable consequences or death. This is supported by Kibonde and Kikuu (2020), who also reported sacred groves as among the traditional conservation techniques employed by the local community in Rungwe, Mbeya.

Selective harvesting

Selective harvesting was a common conservation practice employed, as also reported by Kibonde and Kikuu (2020). This technique was practised in two different ways. In the first case, it was believed that harvesting only the leaves or part of the bark or root would not necessarily kill the plant, as other parts remained intact to support its continued growth. However, this practice was ineffective as some very rare plants, including *W. ugandensis* and *P. africana*, were found to be overharvested despite using only plant barks, thus affecting their survival (Figs. 3 and 4). Therefore, using only certain plant parts, such as seeds, fruit, leaves, bark, or roots, does not necessarily guarantee conservation, as these parts may be overharvested beyond their normal regeneration capacity. Several studies have reported the dwindling of some African medicinal plants (Moyo *et al.* 2015; Van Wyk & Prinsloo 2018; Groner *et al*. 2022). For example, *W. ugandensis* has already been reported to have disappeared in the Forest Mountains in Kenya (Kairu *et al*. 2013), and a study by Dokata *et al*. (2023) has reported the need to map its relative abundance and distribution for informed conservation and management plans.

The second way of selective harvesting of medicinal plants is the belief that harvesting an already harvested medicinal plant will not work and may possibly cause the illness to be inherited in the first case. The traditional healers reported that this was applicable to only a few plant species. When this myth is effectively applied, it may lead to conservation, as there will be no overharvesting of such plants. It is unlike the reported traditional conservation strategies employed by Maasai, which involve sustainable harvesting techniques, collective monitoring, and community resource management structure (Nankaya 2014).

Spiritual guidance in the harvesting of medicinal plants

The majority of traditional healers claimed to have acquired their knowledge through spiritual connections, which they received through dreams. The spiritual-guided healers differed from other users of medicinal plants or traditional healers, who often used medicinal plants without any spiritual connections, and they were renowned for their effectiveness in healing. These spiritually guided healers did not easily declare which plant was exactly used to treat a certain disease, as they were shown through dreams when a sick person came for service. This practice reduced the number of people who went into the wild to harvest medicines and relied more on spiritually guided traditional healers, thereby promoting conservation. A study by Ssenku (2022) also reported that the most common conservation practice among traditional users of medicinal plants was spiritual, while adherence to government regulations was only 4.5%. This shows the power of spiritually guided conservation, as also narrated by Kala (2017).

Domestication of wild medicinal plants

The traditional healers and the community members reported domestication as a way to ensure easy access to medicinal plants and reduce the overharvesting of wild resources. Cultivating these plants demonstrates responsible and sustainable wild harvesting principles to local communities. This helps ensure a consistent supply while minimising the need for wild harvesting. Several studies have reported the need to domesticate medicinal plants to meet the increasing demand (Jeelani *et al*. 2018; Carrillo-Galván *et al*. 2020; Kibonde & Kikuu 2020; Ramawat & Arora 2021). Additionally, during the domestication process, traditional knowledge about the cultivation and use of medicinal plants can be easily transferred to community members and preserved for future generations.

Conclusion

Traditional conservation of medicinal plants is crucial for preserving biodiversity and maintaining natural remedies used in healthcare. It ensures the sustainable use of valuable plant species while protecting indigenous knowledge passed down through generations. By safeguarding these plants, we support ecosystems, promote herbal medicine research, and provide future generations with alternative healing options. Encouraging traditional conservation practices as identified in this study will help to balance modern medicine with nature's wisdom, ensuring long-term health and environmental sustainability.

Declarations

List of abbreviations: IUCN – International Union for the Conservation of Nature; **CITES** - Convention on International Trade in Endangered Species of Wild Fauna and Flora; **WCMC** - World Conservation Monitoring Centre; **FAO** – Food and Agriculture Organisation; **SUARIS** - Sokoine University of Agriculture Research and Innovation Support

Ethics approval and consent to participate: The development of the study followed the ethical and legal guidelines for the development of research on traditional knowledge. The research was reviewed and approved by the SUARIS awarding Committee and registered under SUA's Directorate of Postgraduate Studies, Research, Technology Transfer and Consultancy (Registration number DPRTC/R/126/CSSH/2/2022). The team obtained a research permit from the Permanent Secretary of the Ministry of Local Government and Regional Administration. Subsequent approvals were obtained from the Regional and District Administrative Secretaries, and Ward Executive Officers were notified accordingly. All the participants were informed about the purpose of the study, assured of voluntary participation and their right to withdraw at any time. The research adhered to SUA's ethical code, ensuring informed consent, confidentiality, and respect for participants throughout the process.

Consent for publication: Not applicable

Availability of data and materials: Not applicable

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Authors' contribution: P.A.M. participated in field data collection, data analysis and manuscript development. G.M. Participated in field data collection, data analysis and verification of botanical names. E.L. participated in field data collection, data analysis and drawing a map. F.M. participated in field data collection, especially in the identification of medicinal plants, herbarium preparation and verification of the botanical names. O.S.N. sourced the fund, organised the field activities, participated in data collection and data analysis and reviewed the manuscript.

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