Evidence-based Conservation of Threatened Medicinal Plants in Dry Lands of Kenya: Community Awareness, and Mass Propagation

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Executive Summary

INTRODUCTION: The Kenyan drylands have a rich diversity of medicinal plants with some being endemic to these regions. However, majority are threatened by vegetation clearance for crop cultivation and infrastructure development, largely fuelled by the general perception that drylands are 'waste lands', 'ignorant' of their biodiversity potential and importance to humans. Documented biodiversity potential helps support conservation efforts in a locality. Therefore, this work sought to determine the medicinal value of six dryland hill-top forests in lower eastern Kenya, gather scientific evidence (from traditional medicine practitioners) to support conservation campaigns, and establish two nurseries to conserve the species *in-situ* and establish a medicinal plant garden in the project sites, in collaboration with the local communities.

RESULTS: In all the surveyed remnant dryland hill-top forests, a total of 139 medicinal plant species were documented. Considering the Species of Conservation Concern (SCC), one critically endangered (CR), three vulnerable (VU), one endangered (EN) plant species listed in the International Union for Conservation of Nature (IUCN) Red list of threatened species were recorded. Several are also protected under Appendix II of the Convention on International Trade in Endangered Species (CITES), while others are locally threatened. We established that, Matooi and Nzaui hills study sites had most species globally threatened species, compared to the other sites where this work was done. Further, these two study sites also recorded the highest number of medicinal plant species. *Dorstenia arachniformis* was the rarest with three subpopulations, *Maytenus putterlickoides* on the other hand was the most abundant of all the five targeted medicinal plant species with sixty-nine subpopulations. Other target species were *Capparis tomentosa* with 29, *Fuerstia africana* 31 and *Terminalia brownii*, 41. Two community tree nurseries and a medicinal plant garden were established within the study sites. A total of 1424 tree seedlings including: 296 *C. tomentosa,* 155 *M. putterlickoides*, 103 *D. arachniformis*, 197 *T. brownii* and 253 *F. africana* were propagated and transferred to the wild to boost the *in-situ* populations within the six sites. Other medicinal plants species that were transplanted included 207 *Croton megalocarpus*, 193 *Moringa oleifera*, and 20 *Aloe secundiflora*. An additional 12 species (86 individuals) of rare local priority medicinal plants were planted in the medicinal plant garden for education and demonstration purposes. Two hundred locals were sensitized on the importance of conserving biodiversity; including the five target medicinal plants species; as well to domesticate rare plants species.

CONCLUSION: The results of this ethnobotanical survey confirm that the six dryland hilltop forests in Makueni county hold a great number of medicinal plant species. The presence of four globally threatened and several locally threatened plant species justifies the need to prioritise them for conservation.

RECOMENDATIONS: There was widespread destruction and disturbance within the target sites by the local communities. Therefore, there is the need to heighten sensitization on the importance of conserving these isolated hills as biodiversity habitats, water catchment areas and means of controlling climate invariability and change.

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CHAPTER ONE: PROJECT ORIENTATION

1.1 General Introduction

Historically, plants have been used in both prevention and treating ailments and diseases in human beings and animals. According to the World Health Organization (WHO), traditional medicine refers to the knowledge, beliefs, and medical practices that are based on history and socio-cultural beliefs, and which are used to treat ailments and promote healthy living. Traditional medicine practices are different from scientific medicine and are popularly referred to as alternative, or folkloric. They are passed from community or generation to another in a set up with different cultural beliefs and practices.

According to Borris (1996), the planet Earth is estimated to host about 250,000 to 500,000 species of plants. Less than 10% of these plants are used as a source of food for both people and animals. About 50,000 plant species contain medicinal properties and are thus used for treating diseases (Teklehaymanot and Giday, 2007). As many as 80% of the world's population depend on traditional medicine for their primary health care (Azaizeh *et al.* (2003).

Plants have been used as food and medicine for humans since the history of mankind. The earliest known evidence of medicinal plant use comes from the Sumerians in Mesopotamia, who recorded the use of plants such as myrrh and opium around 3000 BCE (Teall, 2014). Other ancient civilizations, such as the Egyptians, Greeks, and Romans, also relied heavily on plant-based medicine. The Greek physician Hippocrates, who lived in the 4th century BCE, is known as the "father of modern medicine" and used plants extensively in his treatments (Yapijakis, 2009). Traditional Chinese Medicine also has a long history of using plant-based remedies, with written records dating back to the 3rd century BCE. In many indigenous cultures around the world, plants continue to play an important role in healing practices and are often used in combination with other traditional healing methods.

Among the African people, the use of traditional herbal remedies has been part of cultural and religious life. According to Steenkamp (2003), the seemingly wide use of traditional medicine in Africa is attributed to their accessibility, affordability, and cultural acceptability. World Health Organization (2003) approximates 80% of the African population use traditional herbal medicine for primary health care. According to Kassaye and colleagues

(2006), the 16 first line of treatment for 60% of children with high fever resulting from malaria is the use of herbal medicines at home in Ghana, Mali, Nigeria, and Zambia. Similarly, traditional birth attendants help in most of births in several African countries (Bannerman *et al.,* 1983). Most people in developing countries lack access to essential medicines, therefore, provision of safe and affordable traditional and complementary alternative medicine (TM/CAM) therapies are critical in enhancing access to health care.

In Kenya, over 70% of population use local home-made remedies as their first source of medicine, while more than 90% used plant-related remedies at one time or another (Kipkore *et al.,* 2014). Similarly, 90% of people in Kenya have used herbal medicine at least once in treatment of various health conditions (Chirchir *et al.,* 2006). Many rural communities in Kenya have a rich tradition of using medicinal plants for the treatment of various ailments, and this knowledge has been passed down through generations. Today, in these rural communities, the use of medicinal plants is not just a traditional practice, but an essential part of the healthcare system largely because access to modern medicine is limited.

In Kenya's rural setting, traditional healers are the primary source of healthcare, and they rely heavily on the use of medicinal plants. These traditional practitioners have accumulated vast knowledge of local medicinal plants through trial and error, observation, and passed-down traditions. Further, they have developed a sophisticated understanding of the local plants' properties, used parts, and how to prepare them for use. Recently, there has been an increasing interest in the use of medicinal plants in African countries more than synthetic medicine. Many of these plants contain active compounds that have been shown to have potential health benefits, and scientists are working to better understand the mechanisms by which these compounds work.

Unfortunately, these plants or their habitats are increasingly becoming threatened. Similarly, this essential practice is not safe either as cultural values are being eroded. Adoption of the western ways of life has, as a result, led to less of this knowledge being transferred to the next generation. This traditional knowledge in many Kenyan ethnic communities remain untapped because medicinal plants have not been fully documented and the information is locked within the older generation thus posing danger of being lost.

Additionally, these vital medicinal plants are being threatened by climate change, livestock browsing, and indiscriminate clearing to pave way for crop farming. Also, selective logging for timber, firewood and other products derived from natural resources has led to habitat degradation/loss and hence loss for biodiversity. Over-exploitation and unsustainable harvesting of natural resources pose great threats to the availability of medicinal plants in most developing countries, thus highlighting the need for evidence-based conservation and viable use of priority plant resources.

1.2 Statement of the Problem

Plant species are rich in small multiple compounds, and they interact with each other during disease healing process (Kaigongi *et al*., 2020), with several secondary metabolites synthesized from plants having been approved for clinical use (Argrawal *et al*., 2020). Due to the limited access to modern healthcare, some local communities use plants in both primary healthcare and palliative care. The dry lands of Kenya are endowed with rich diversity of medicinal plants. However, the majority are threatened by vegetation clearance for crop cultivation and infrastructure development, largely fueled by the general perception that dry lands are 'waste lands', 'ignorant' of their biodiversity potential and importance to humans. Documented biodiversity potential encourages conservation efforts and initiatives in a locality.

In Kenya, 80% of landmass consists of arid and semiarid lands (ASALs) (Kigomo, 2001). These are endowed with a rich diversity of medicinal plants. Kenya is a home of 6,293 indigenous vascular plant species (Zhou *et al.*, 2017), of which over 5,000 plant species are found in drylands (Grace *et al.,* 2010). Unfortunately, this great wealth of dryland biodiversity and its indigenous knowledge is not well documented (Ali, and Businge, 2011). According to Vasisht and Kumar, (2004), an estimated 1,200 plant species in Kenya are of medicinal value. In Kenya's drylands, which has over the years attracted less studies, much of these medicinal plant species are undocumented and it is therefore regrettable that this great potential is being lost as a result of preventable means. Further, the majority are threatened due to logging and bush clearing for agricultural practices, with the perception of dryland as less important/wastelands, and ignorance of their biodiversity potential and importance to humans. Therefore, evidence-based approach is an effective way of campaigning for the conservation of the remaining dryland hilltop forests and the great biodiversity in them including threatened and endemic species.

Makueni county in south-eastern Kenya has several isolated dryland hilltop forests that are endowed with rich diversity of plants including those with medicinal values. It leads in the practice of using traditional medicine to treat common diseases in Kenya. However, majority of the medicinal plants in the remnant forest patches (e.g, *Capparis tomentosa, Fuerstia africana, Terminalia brownii,* etc) are facing extinction due to over-exploitation (destructive root digging, bark peeling, etc) and deforestation activities (Gakuya *et al.*, 2020). Further, recruitment or the growth rate of some of these species is very slow, hence the need for assisted propagation and high community awareness.

Despite the evident threats, there are little or no active conservation actions in the area (especially targeting medicinal plants), as most conservation efforts are directed to rain forests, neglecting the seemingly undervalued dryland hilltop forests. These remnant hilltop forests are 'forgotten' but not lost, as citizen scientists and nature enthusiasts including traditional medicine practitioners continue to expose their potential. They have failed to attract more research due to scarcity of information regarding their value. Therefore, this study sought to bridge this gap by providing more evidence on the medicinal plant's potential of the sites.

1.3 Justification of the Project

Terminalia brownii is locally threatened by the increase in settlement and expansion in agriculture. Its hard wood is resistant to termite attack and thus selectively logged to provide fencing poles within the study area. Domestication and propagation efforts have proven difficult due to challenging seed germination and dormancy. Thus, urgent measures need to be implemented to save the species from diminishing trends. *Fuerstia africana* despite having multiple medicinal benefits, is still regarded as a weed in the area. It requires wet or shady areas for survival and because of the ongoing global warming especially in drylands it is currently restricted to hilly areas. *Maytenus putterlickoides* and *Capparis tomentosa* are equally threatened by vegetation clearance, overgrazing, and changing climatic patterns in the area.

Conservation of medicinal plant species is an important step towards preserving biodiversity, intangible cultural heritage, promoting medical advancements, and economic development. Therefore, conserving threatened medicinal plant species within the study sites is anticipated to have spill-over effects on the conservation of other species in the area. One of the target

species, *Dorstenia arachniformis* is only known from the locality and it is critically endangered based on the IUCN criteria and categorization. This species is habitat shade-dependent, greatly impacted by the ongoing vegetation clearance and unreliable rainfall in the area. Therefore, conservation of *Dorstenia arachniformis* within the hilltop fragments also calls for protection of other woody species that depend on shade.

The loss of these crucial species can have a cascading effect on other species and the overall biodiversity of the ecosystem. For example, they serve as habitat, food sources for animals and insects, and their presence helps to stabilize soil and thus erosion control. Further, *Millettia vatkei*, an endangered medicinal plant occurring in south-eastern Kenya supports many animals for food. According to Munywoki *et al* (2021), rock hyraces within the study sites have shown great preference for *Millettia vatkei* as food and habitat.

Other seed-eating animals (granivores) common in the study area and that heavily rely on the same threatened medicinal plants include, the wild rodents (field mice) and ochre bush squirrel (*Paraxerus ochraceus*). Similarly, *Millettia vatkei* provides forage for bees. In return these animals reciprocate by assisting in seed dispersal and pollination. Consequently, this mutual relationship is collapsing because of decreasing populations of *Millettia vatkei*. Therefore, by conserving threatened medicinal plant species, we are also helping to protect other species that rely on them for their survival.

Importantly, the conservation of threatened and vulnerable plants bears a cultural significance through the preservation of local cultural heritage. Many traditional healing practices and rituals heavily relied on the use of medicinal plants. The extinction of medicinal plants poses a great threat to the loss of cultural diversity including traditional knowledge systems that have been preserved for hundreds of years (Yirga, 2010; Hamilton, 2003). *Dorstenia arachniformis* Malombe, Matheka, Mwadime and Mwachala (2020) is a critically endangered medicinal plant species recently described from the study area and that has great cultural significance among the local community (Malombe *et al.*, 2020). This target medicinal plant species has been used for spiritual cleansing among the Kamba community for years. In this effort, by conserving these medicinal plants, we hope to also preserve vulnerable traditional knowledge and cultural practices that have been passed down through generations.

Medicinal plants are a source of income for many communities globally. They are often harvested and sold as raw materials or processed into medicines, herbal remedies, cosmetics, and other products. The significant contributions of medicinal plants to local economies and ultimately people's livelihood, specifically the rural poor, have received wide attention (Okigbo *et al.,* 2008). Recently, there has been a huge trade for medicinal and aromatic plants on local, regional, and international level thus increasing the demand in botanicals for both domestic usage and for commercial trade. Medicinal and aromatic plants are beneficial as herbal remedies, medicinal tea, cosmetics, and dietary supplements. These represent a significant part of the natural biodiversity endowment of many countries in Africa including Kenya. Therefore, by conserving these medicinal plants, we anticipate making great contributions to improving the local's well-being through generation of extra income.

Additionally, medicinal plants form an essential part of the local watershed ecosystem, and their loss negatively impacts the ecological balance such as unreliable water supply. Coincidentally, the study sites fall within the catchment area for Thwake multi-purpose dam, a flagship project of the Kenya's vision 2030 blueprint. The dam is also cited as a key enabler for the realization of Kenyan government's big 4 Agenda comprising of affordable healthcare; food security and nutrition; affordable housing and manufacturing. Therefore, conservation of the target medicinal plants and their habitats also conserves Thwake dam catchment area (the study sites). The project is in line with the Makueni county climate change policy and the Makueni county vision 2025 that among other things call for protection and management of water catchment areas and wetlands.

1.4 General Project Objective

This study sought to promote the conservation of threatened medicinal plants in drylands (Makueni County drylands in the bigger picture), using prior evidence that the drylands contain medicinally useful plants (among other equally "useful" plants). Hence, gathering of ethnobotanical data in the study area was used as evidence base to support our call for conservation activities among relevant stakeholders. Moreover, it exposed the medicinal potential of isolated remnant dryland hilltop forests in Makueni county as evidence to strengthen the conservation of threatened medicinal plant species in the area.

1.4.1 Specific Objectives

The specific objectives of this study were: -

1. To undertake ethnobotanical survey in six isolated dryland hilltop forests fragments in Makueni subcounty (Nzaui, Nzueni, Matooi, Kwa Matheka) and Mukaa subcounty (Kiou and Kenze), prioritizing mapping of the 5-target threatened medicinal plants and gathering of other ethnobotanical information.

2. To undertake mass-propagation of the five-target threatened medicinal plant species including other species of medicinal importance and restore them in the wild to boost the *in-situ* populations. Establishment of a medicinal plant garden to serve as a center for conservation, education, and demonstrative purposes.

3. To create conservation awareness among the local community within the study area on the importance of conserving and sustainable use of natural resources including medicinal plant species.

CHAPTER TWO: BACKGROUND INFORMATION

2.1 Conceptual Framework

It is important to understand how local communities use and manage natural resources in promotion of a conservation agenda (Duchelle, 2007). They are often the first and most impacted by changes in natural resources, and they have a deep understanding of the local environment and its ecological processes. Their knowledge and practices inform effective conservation strategies and help ensure that conservation interventions are sustainable and socially equitable. Ethnobotanical and traditional ecological knowledge studies have been known to bridge the gap between conservationists and local communities. These studies determine the locals' relationship with the environment and thus call for their active involvement in conservation of those natural resources.

According to Bagine (2006), empowering local communities to participate in biodiversity conservation and sustainable use is a key strategy for promoting both environmental and social sustainability. The collection and marketing of traditional medicinal plants from the wild is perceived as an important source of livelihood for many poor rural communities in developing countries (Hishe *et al.,* 2016; Alam and Belt, 2009). Drylands have some of the highest levels of poverty thus they rely solely on natural resources for their livelihoods. For instance, some local communities sale collected wild medicinal plants to generate some income. According to Hamilton (2009), almost one third of medicinal plant species could become extinct, with most losses being reported in Kenya, Tanzania, and Uganda among others. These losses are anticipated to be severe in arid and semi-arid areas because of climate variability and change, over-exploitation, agricultural expansion, overgrazing and recent surge in global trade in medicinal and aromatic plants (Ayyad, 2003; Wezel and Rath, 2002).

2.1.1 Evidence-based Approach to Conservation

For the last decade or so, there has been a renewed attempt to provide an evidence-base to underpin decision making for conservation of remnant dryland hilltop forests. However, this is much needed perhaps by the local communities than all other stakeholders as they interact with nature in their day-to-day activities. The locals are eager to attach value to conservation and prompt answers of doing so. What benefit do we get from this as opposed to that? Such

locals value attachments to places, species, and actions greatly influence environmental decisions. Highly valued attachments promote protection or/and sustainable utilization of natural resources thus encouraging pro-conservation attitudes and perceptions.

Conservation efforts have succeeded best when supported by tangible evidence of the benefits of biodiversity (Isbell *et al*., 2017). For instance, Kioko *et al.*, (2021) clearly exposed the socioeconomic importance of butterflies in Taita hills to support their conservation campaign. Similarly, Beck & Lange, 2017 attached an economic value to mangroves to campaign for conservation in Philippines. Therefore, in all these conservation exercises, locals need to see solid evidence of flow of benefits in order to buy and implement in conservation interventions.

2.1.2 Why Conservation through Medicinal Plants?

Conservation of biodiversity within Kenya's arid and semi-arid lands (ASALs) endeavors to promote genetic diversity, continuous supply of natural resources and provision of ecosystem services for the local communities. Determining the potential entry points to such conservation initiatives requires identifying features or needs of local communities that are pro-conservation, and then finding ways to support or encourage them. Medicinal plants offer such opportunities as the local community (*Akamba*) have always attached value to them for the various benefits derived. They, therefore, serve as source of motivation for conserving them and their habitats. Traditional herbal medicine assumes great prominence within the study sites (Ukambani) and thus good evidence to base biodiversity conservation campaigns.

To achieve the much-needed conservation outcomes, all socio-ecological conservation needs for the project were carefully considered during the implementation. All the project activities were appropriate for local livelihood, feasible for the village setting and were socially acceptable in terms of costs and benefits. For example, the choice of study sites was carefully considered to promote the intended goals of the project. We chose dryland hilltop forests within the *Combretum*-wooded grasslands of Makueni county as these will add much value to the conservation of genetic diversity, and the provision of ecosystem services such as soil stabilization and water supply which are some of the main challenges within the study sites.

Further, to strengthen conservation, we identified five threatened medicinal plants and prioritized their conservation within six isolated dryland hilltop forests for improved

management. Similarly, we encouraged the cultivation (domestication) of local priorities of medicinal plants in locals' homesteads. Further, we documented local knowledge of medicinal plants, established a medicinal plant garden to serve as cultural center for conservational education and demonstration purposes. Finally, we sensitized the locals to raise their awareness and appreciation of local biodiversity and culture.

2.2 The Study Site

This study was undertaken in six isolated dryland hilltop forest located within two sub-counties (Makueni sub-county: Nzaui, Nzueni, Kwa Matheka, and Matooi hills; Mukaa sub-county: Kenze and Kiou hills) of Makueni county. These study localities are predominantly occupied by the Kamba (*Akamba*) community who are renowned for their vast knowledge in traditional herbal medicine. They have a long history of ethnobotany, dating back to the pre-colonial era as evidenced by their famous medicine man and woman: Masaku and Syo Kimau.

The study area receives two rainy seasons, long rains in March to June, and short rains in October to December. The rainfall regime in these sites is greatly influenced by altitude. Low-lying areas receive little rainfall which increases with altitude. These isolated hills form part of the upland dry forests of Makueni County, in lower eastern Kenya, and are characterized by patchy and fragmented semi-evergreen forests, and intense human encroachment. This habitat fragmentation has been brought about by vegetation clearance for crop farming and settlement, a common practice in the region.

The natural vegetation within the study sites varies from place to place. The once forested hilltops have been cleared over time to create room for farming (Silberfein, 1984), and plantation farming especially *Eucalyptus* species. This has left patches and corridors of natural vegetation along ranges, rivers, and hilltops. The remnant vegetation plays an important role as they connect habitats and act as steppingstones for migrating species. On the higher hilltops (above 1700 m a.s.l), they are dominated by remnant evergreen forest vegetation and evergreen thicket clumps in grassland. On the low-lying areas or plains there are *Acacia-Commiphora* bushlands and grasslands, which give way to *Combretum*-woodland grassland on the mid-elevation.

Nzaui hill is the only site among the six that enjoys legal protection from the government. It is gazetted and managed by the Kenya Forest Service (KFS). The other five are unprotected and thus over-exploited by the local communities due to lack of awareness of their potential. Notwithstanding, these isolated hills have a high floral richness and great concentration of rare, unique, and endemic plant species. Similarly, they are endowed with a lot of medicinal and aromatic plants, the majority of whom are locally threatened by destructive anthropogenic activities and climate invariability and change.

These hills deserve to be accorded special conservation attention if the locals are to continue enjoying the provision of ecosystem services and if the great diversity in them is to be retained. However, due to little research attention given to the area, the ethnobotanical potential of these hills is not well documented, hindering the design of practical conservation actions for them.

2.3 Target species

The study area is a home of multiple medicinal plants species that have over the years been over-exploited for their medicinal values. However, this study targeted five medicinal plant species as priority for conservation based on their perceived threats.

2.3.1 *Dorstenia arachniformis* Matheka, Malombe, T. Mwadime & Mwachala

Dorstenia arachniformis is endemic to the open deciduous *Combretum*-wooded grasslands of south-eastern Kenya with known populations in less than 4km^2. It is critically endangered based on the IUCN criteria and categories. It is used in the *Akamba* spiritual cleansing, sometimes in combined form (Malombe *et al.*, 2020).

2.3.2 *Terminalia brownii* Fresen

It is a deciduous tree with a brown trunk distributed in savanna and semi-arid regions in East Africa with moderate rainfall. It belongs to genus *Terminalia* of Combretaceae family. It has various medicinal applications such as treating tuberculosis, diabetes, yellow fever, and eye cataract. It is locally threatened as it is greatly affected by the increase in settlement schemes and expansion in agriculture, threatening its sustainability. Because of its hard wood resistant to termite attack, it has been selectively logged to provide fencing poles within the study area. Despite the species' threats, domestication/propagation efforts have proven difficult due to

challenging seed germination and dormancy. Thus, urgent measures need to be implemented to save the species from diminishing trends.

2.3.3 *Capparis tomentosa* Lam

It is a deciduous, thorny scrambling shrub, sometimes growing and developing into a tree up to 10m tall. This plant species belongs to the family Capparaceae and the genus *Capparis*. Although *C. tomentosa* is fairly distributed in Eastern and Southern parts of Africa, it is being eradicated and destroyed from most habitats in Eastern Kenya due to increased farming activities, browsed by goats, and lack of awareness. In herbal and traditional medicine, it is used to treat snakebite, pneumonia, and infertility among other uses.

2.3.4 *Fuerstia africana* T.C.E. Fries

It is a leafy perennial shrub which seasonally grows in dry tropical biome. It belongs to genus *Lannaeae* of family Lamiaceae. It is used to treat malaria and high blood pressure. Further, it is widely regarded as a weed, thus normally eradicated without regard to its medicinal value. Due to this negligence of protection, and change of climate, this species now thrives only in mountain areas (less disturbed) where there is sufficient rainfall. Although it is documented as a species of less conservation concern in Eastern Africa, the aforementioned factors threaten the natural existence of this species.

2.3.5 *Maytenus putterlickoides* loes (A. Rich)

This plant species belongs to the family Celastraceae and genus *Maytenus.* Although *M. putterlickoides* is used to treat diarrhea, convulsions, malaria, and other diseases in many local communities, it is not properly conserved. Over-exploitation and drought have adversely affected the growth of this species.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Data Collection

Before inception of the project, prior informed consent was sought from the key informants through informal meetings and discussions held with the local administration.

3.1.1 Ethnobotanical Information of the Local Medicinal Plants

Community involvement or participation has become a key component of conservation interventions at the grass roots. To achieve the desired outcomes, participation needs to be involved from appraisal to monitoring and evaluation. Therefore, the study used mainly participatory action research (PAR) and participatory rural appraisal (PRA) approaches involving 11 individuals (comprising 7 men and 4 women) of mixed ages between 40 and 84 years. The chain referral method employing purposeful sampling technique was used as a tool for identifying key informants who were knowledgeable about the local medicinal plants, methods of preparation and diseases or ailments treated. Those with wide knowledge of ethnobotanical plants of the larger Ukambani region and importantly with deeper understanding of Kamba ethno-social and cultural systems of livelihood were recruited to participate in the study.

For this study, random sampling could not hold as not everyone sampled randomly could have posed the needed ethnobotanical experience or knowledge (McCorkle *et al.* 1997). Therefore, we purposely sampled specific categories of people within the community who had ethnobotanical knowledge. Oral interviews were conducted to administer questionnaires to the selected traditional medicine practitioner who were knowledgeable about medicinal plants in Makueni, and the preparation of decoctions. We prepared a detailed questionnaire to make it easier to obtain the information. Further, we recorded a short video (capturing the interviews, and demonstrated preparation of decoctions) for sharing with the public and scientific community.

3.1.2 Botanical surveys within the study sites

After undertaking oral interviews with the selected key informants, a botanical survey was conducted within the six-target dryland hilltop forests to identify and map the distribution *C. tomentosa*, *F. africana*, *T. Browni, M. putterlickoides,* and *D. Arachniformis* and other medicinal plants. Similarly, we collected some plant materials for demonstration of medicinal drug preparation. Seeds and other botanical materials used in propagation were collected

during this period. The surveys followed a general walk-over sampling, putting into consideration the ecological preferences of each target species. The project team was accompanied in the field by a key informant who also assisted in identifying and collecting specimens for identification. Plant identification was based on the Flora of Tropical East Africa (FTEA).

After collection, the plant parts were labelled and stored at room temperature. On every encounter of the target species within the study sites, GPS coordinates were taken, and medicinal uses recorded with the help of the knowledgeable medicine man or woman. Similarly, the part of the plant used to prepare medicine, method of preparation, mode of administration as well as number of patients treated were recorded. This exercise was also reciprocated to the other encountered medicinal plants. This was done with the assistance of the traditional medicine practitioners who were experienced in using medicinal extracts for treating a variety of diseases.

3.1.3 Mass Propagation of Medicinal Plant Species

Two non-mist propagators were established, one in Mukaa and the other in Makueni sub-counties for propagating the collected seeds and other plant materials. Further, a medicinal plant garden for education and demonstrative purposes was established in Mukaa sub-county. Seed collection exercise for the priority medicinal plants species was carried out within the six target sites with the help of local community members. Before the collection, they were trained in seed collection and handling protocols, choice of seed sources (mother plants) and propagation as a way of ensuring viability and diversity. During seed collection within the sites, well-performing mother plants were chosen for seed collection at least at an interval of 100 meters from each other. The cutting test was used in determining the health and maturity of the seeds.

In circumstances where seeds were not available, stems were propagated for the case of *Maytenus putterlickoides*.

The dried seeds were propagated in a non-mist propagation system. While much of the seedlings were transplanted into the wild to boost the *in-situ* populations, a sample of local priority medicinal plants such as *Aloe* sp. were grown in the established medicinal plant garden. For the medicinal plant garden, a suitable terrain was considered to establish the

ecologically sustainable garden for the medicinal plants. We sought to keep the garden as natural as possible by minimizing digging and fencing for protection.

3.1.4 Creation of Conservation Awareness among the Local Community

To sensitize the local community and campaign for the conservation of drylands, awareness workshops, seminars and meetings were organized within the selected project sites to 'sell' the idea to the locals. Regular meetings were conducted in the villages, facilitated by the project experts and local leaders. Demonstrations entailed using live specimens of various target species, posters, short videos, and other educative items to advocate for environmental protection and conservation.

CHAPTER FOUR: RESULTS AND DISCUSION

4.1 Project Inception and Reconnaissance

We conducted a 2-day reconnaissance survey to familiarize ourselves with the six study sites and met with the locals who were stakeholders in the project. We introduced the project objectives and goals to the locals as well as highlighted the stakeholder's roles in the project. In line with this, we introduced the five target medicinal plant species using life specimens. The target medicinal plant species included *Terminalia brownii* Fresen, *Fuerstia africana* T.C.E Fries, *Capparis tomentosa* Lam, *Maytenus putterlickoides* loes (A. Rich), and *Dorstenia arachniformis* Malombe, Matheka, Mwadime and Mwachala.

4.2 Ethnomedicinal Knowledge and Information of the Study Sites

Eight (8) key informants (traditional medicine practitioners) comprising of 7 men and 1 woman of ages ranging from 40 to 84 were interviewed (Figure 1).

FIGURE 1: An interview with some of the local traditional medicine practitioners

They were co-operative and knowledgeable about the local medicinal plants in the area. We recorded their experience on herbal medicine, including the plants used in the treatment of various diseases, preparation methods, administration methodology and number of patients treated (Figure 2). Notably, some drug preparation involved use of more than one plant part or other plant parts (see figure 3) to increase their healing effect (efficacy).

FIGURE 2: Preparation of traditional herbal medicine through grinding using mortar and pestle

Other preparation methods involved boiling the various plant parts to produce decoction which is the most common preparation method of traditional herbal medicine (Figure 3). These plant parts are usually boiled to help in extracting the active ingredients from medicinal plant parts. Similarly, it helps preserve the herbal remedy for longer time than that of using cold extraction (Kamatenesi *et al.*, 2011).

FIGURE 3: Preparation of decoction by traditional medicine practitioner

According to Moshi and colleagues (2010), boiling for an extended time sometimes result to negative outcomes, such as the degradation of bioactive ingredients especially the aromatic compounds. Therefore, the practioners advised on timed boiling which requires prior knowledge since not all medicinal plants demand the same duration of boiling.

4.3 Ethnobotanical Survey within the Study Sites

Six (6) isolated target study sites were surveyed within Makueni county; Nzaui, Nzueni, Kwa Matheka, Matooi from the Makueni subcounty and Kenze and Kiou from Mukaa

subcounty. Previously, four sites were planned to be surveyed, however, two more sites (Matooi and Kwa Matheka) were later included due to existence of relatively intact patches of natural vegetation that deserve to be conserved. Also, recent records of new species such as *Aloe ngutwaensis* (Matheka *et al.,* 2020), and *Dorstenia arachniformis* (Malombe *et al.,* 2020) were discovered from these sites and thus the need for continued exploration and sensitization. Therefore, it was important to include these sites in the survey as locals' awareness of their potential is crucial for future survival of the species. During the field survey, various parts of the different medicinal plants were demonstrated to us by the traditional medicine practitioners (Figure 4).

FIGURE 4: Field demonstrations by the key informants within the study sites

4.4 Mapping of the Target Medicinal Plants Species and Others in the Study Sites

The team conducted a botanical survey to identify, map and estimate the population of the target threatened medicinal plants and other medicinal plant species in the designated study sites. We mapped 3 subpopulations for *Dorstenia arachniformis,* 29 for *Capparis tomentosa,* 31 for *Fuerstia africana,* 41 for *Terminalia brownii* and 69 for *Maytenus putterlickoides* (Figure 5). Among the six localities, only Nzaui and Matooi are endowed with the five targeted medicinal species (Figure 5). Similarly, they had the highest number of subpopulations for the target species, which highlights the need for continued conservation interventions and heightened awareness among the locals. This is also supported by the presence of *Dorstenia arachniformis* and three other threatened medicinal plant species (*Millettia vatkei, Pavetta teitana* and *Euphorbia friesiorum*) under the IUCN criteria. Nzueni

hill had the least number of the target medicinal plants with 20 subpopulations (Figure 5), possibly owing to its rocky and dry conditions.

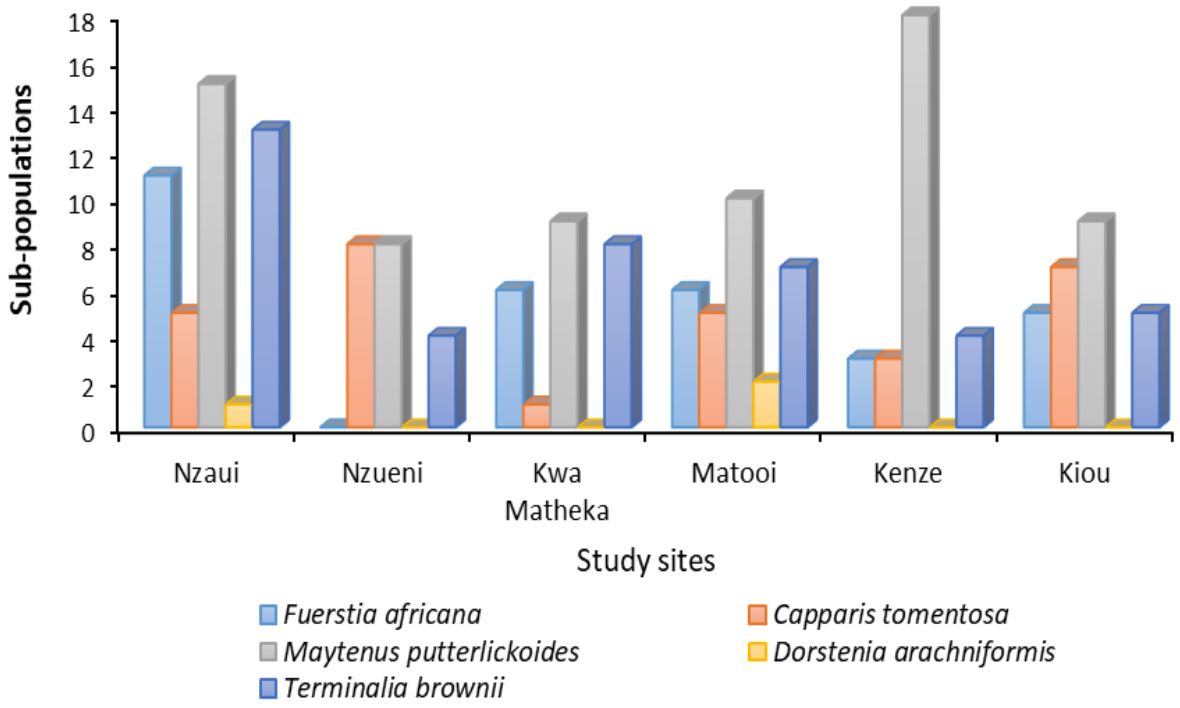

FIGURE 5: Target medicinal plant species subpopulations per sites

Apart from the five-target species, this study identified and mapped other medicinal plant species within the study sites. Kiou and Matooi hills had the largest number of other medicinal plant species with 37 and 30 plant species respectively (Figure 6). Nzueni and Nzaui had the least number of other medicinal plants species mapped, perhaps because larger part of Nzaui hill forest is dominated by *Eucalyptus* sp plantation and a sizeable area under rock outcrop. *Eucalyptus* sp has been known to exhibit allelopathic effects that prevent the co-occurrence of other plant species (Bayle, 2019; Islam and Rahman, 2020; Hoogar *et al.*, (2019). Nzueni hill is characterized by very rocky and dry conditions that discourage vegetation growth. Generally, Kiou hill had the highest number (41) of medicinal plants species recorded followed by Matooi with 35 medicinal plant species. In Nzueni hill and its surrounding area, we mapped 14 species, 35 in Matooi, 18 in Kenze, 41 in Kiou, 15 in Nzaui hill and 16 at Kwa Matheka (Figure 6).

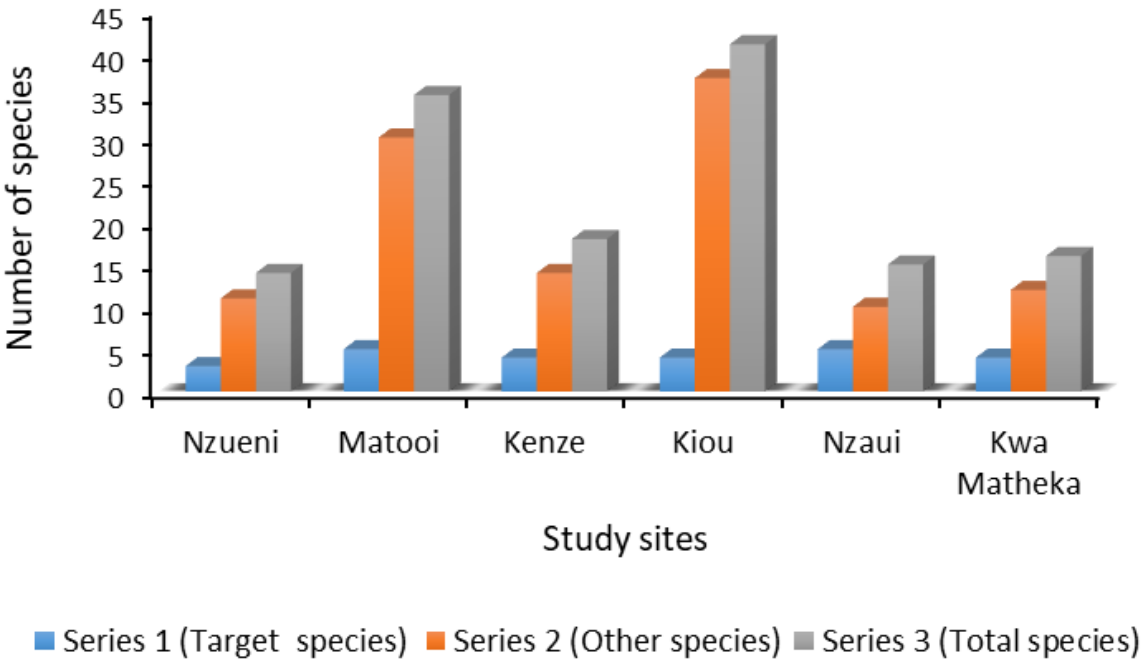

FIGURE 6: Medicinal plant species in the respective study sites

Among the target plant species, *Maytenus putterlickoides* had the highest populations of 69 and *Dorstenia arachniformis* the least with 3 populations only. *Dorstenia arachniformis* is a newly discovered plant species within the study area and which is critically endangered under the IUCN criteria and categories (Matheka and Malombe, 2022). The species is known from only one location with less than 100 mature individuals in scattered subpopulations. During our field exploration, two of the previously known subpopulations could not be traced and therefore feared lost or greatly disturbed. However, we managed to find a new subpopulation at the base of Nzaui hill in a private farmland, occasionally grazed especially during dry seasons. Unfortunately, the subpopulation was located at a road junction and highly likely to be lost should the road be expanded in the future.

The current population trend for the *Dorstenia arachniformis* is decreasing as a result of habitat loss, over-harvesting for traditional rituals by locals and also being fed by snail (Matheka and Malombe, 2022). Additionally, this species is habitat and shade-dependent therefore it has been greatly affected by selective logging of woody plant species and climate invariability and change.

Importantly, from the medicinal plants recorded we compiled a list of species of conservation concern as per the study sites. A total of four threatened medicinal plant species under the

IUCN criteria and categories were recorded within the six study sites. These are, *Dorstenia arachniformis*, *Millettia vatkei*, *Pavetta teitana* and *Euphorbia friesiorum*.

All unlike Kiou and Kenze hill, had a record of any of the four threatened medicinal plant species (Figure 7). While Nzaui and Matooi recorded all the four threatened plant species, Kwa Matheka and Nzueni had a record of three plant species. Further, all the study sites had at least one plant species protected under Appendix II of the Convention on International Trade in Endangered Species (CITES). They include, among others, *Osyris lanceolata*, *Aloe secundiflora*, *Sclerocarya birrea.* Plant families Fabaceae, Lamiaceae, Euphorbiaceae and Combretaceae were the most represented in the recorded medicinal species.

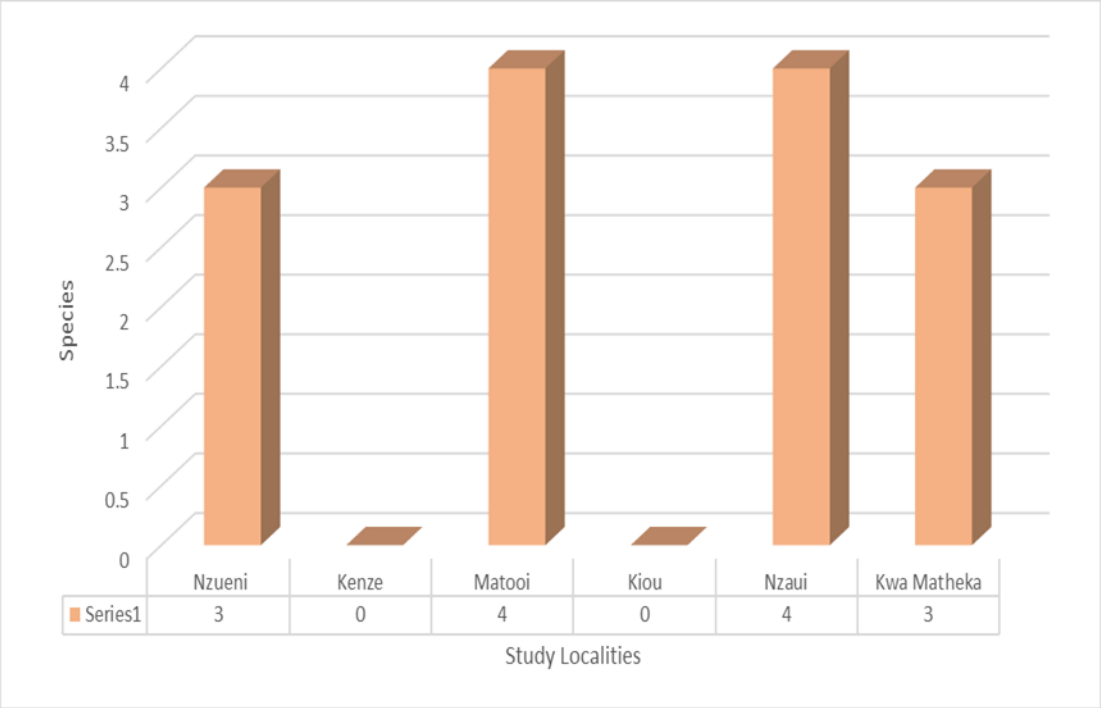

FIGURE 7: Medicinal plant species threatened under the IUCN criteria

Some of the commonly used medicinal plants species documented within the study sites include *Fagaropsis hildebrandtii*, *Zanha africana*, *Zanthoxylum chalybeum* Engl., *Aloe secundiflora* Engl., *Plectranthus comosus* Sims, *Uvaria scheffleri*, *Croton megalocarpus* Hutch. *Euclea divinorum*, *Senna siamea*, *Pappea capensis*, *Ximenia americana* L, *Dalbergia melanoxylon*, *Securidaca longipedunculata* Fresen and *Steganotaenia araliacea* Hochst among others. Interestingly, majority of the above medicinal plants were reported by the traditional medicine practitioners (key informants) to be rare in the wild. Similarly, the results

of the study echoed similar previous findings by Kisangau and Herrmann (2007) who recorded similar decreasing trends elsewhere within Makueni County.

Another issue highlighted from the results is the level of protection and management of the target study sites. The choice of sites considered both protected and unprotected areas and their effects on the medicinal plants. Among the target study sites, Nzaui hill forest was the only gazetted and protected forest. It is therefore evident from the results that much of the medicinal plant species were recorded from unprotected communal or privately-owned lands that are prone to land use changes. This means that there is an urgent need for enhanced awareness creation among the local communities.

We note that Kwa Matheka is a privately-owned land that has a relatively large intact natural vegetation. Similarly, in Matooi hill there are large tracts of private land with intact natural vegetation although within the last decade or, so Eucalyptus plantation farming has been established. Interestingly, these sites recorded the highest number of threatened medicinal plant species under the IUCN Red List of threatened species. It is worth noting, Matooi hill hosts the largest population of critically endangered and medicinally useful *Dorstenia arachniformis*, recently described from the area and other species of conservation concern.

These results support recent findings of a rapid herpetological survey in the area that reports Matooi hill as having the most amphibian and reptile species compared to the surrounding hilltop forests despite being unprotected (Malonza *et al.*, 2023). Two Afromontane restricted range species, namely Mt. Kilimanjaro Forest Lizard (*Adolfus kibonotensis*) and Mt. Kilimanjaro five-toed Skink (*Leptosiaphos kilimensis*) were recorded. According to Malonza and others (2023), these montane hill-top forests are part of the eastern Africa Afromontane biodiversity hotspot. Such sentiments were echoed by Sebsebe and others (2017), who opined south-eastern Kenya being an emerging biodiversity hotspot, whose biodiversity uniqueness compares to the Eastern Arc Mountains Biodiversity Hotspot (Young, 1984). Therefore, these accumulating pieces of evidence justifies these isolated hills in Makueni county to be accorded priority in conservation by being listed as a Key Biodiversity Area in Kenya.

4.5 Mass Propagation of the Medicinal Plant Species

We engaged the locals and established two tree nurseries using non-mist propagation system each in Mukaa and Makueni sub-counties for the propagation of the target and other medicinal plant species. Before propagation, we conducted two training exercises with some members of the local community on seeds' collection and handling procedures. The choice of seed sources (mother plants) was emphasized as a way of ensuring viability and diversity. During seed collection, well-performing mother plants were chosen for seed collection at least at an interval of 100 meters apart. The cutting test was used to determine the health and maturity of the seeds. Both crown and ground seed collection methods were used (Figure 8).

FIGURE 8: Seed collection by locals within the target study sites

After collection, the seeds were extracted, dried, and stored at room temperature before sowing (Figure 9). The seeds were stored in khaki bags and properly labelled.

FIGURE 9: Seed processing before sowing

Two tree nurseries were established making use of non-mist propagation system (Figure 10). They were established using dry wood logs and other locally available materials. This idea was adopted to minimize further cutting of trees. The two tree nurseries measured 5 × 8 M each. The whole external structure was lined with a green 75% mist net to prevent much sunlight penetration (Figure 10). This net only allows penetration of 25% light into nursery beds minimizing water loss and thus less irrigation frequency. Grass mulching was also used to cover the nursery beds to minimize further water loss.

FIGURE 10: The established propagation nurseries

Besides, all the nursery beds had polythene linings to reduce any water seepage reducing excess water loss (Figure 11).

FIGURE 11: Sowing of seeds in the established nursery beds

Propagation of some target medicinal plants such as *M. putterlickoides*, *T. brownii* realized some germination challenges and therefore we used cuttings to propagate them. Rooting hormone was used to enhance rooting efficiency. Plant cuttings were also used when the mother plant had no fruits/seeds for collection.

Occasionally, the nurseries were sprayed to prevent snails and other destructive insects such as crickets and termites from destroying the young seedlings. For example, we encountered this great challenge with the propagation of *D. arachniformis* which is preferred by snails because of its succulent stems. The raised seedlings were transferred into potting tubes after attaining 2-4 leaves (Figure 12).

FIGURE 12: Locals transplanting seedlings from nursery bed into potting tubes

The seedlings were further hardened before transplanting into the designated sites within the study localities (Figure 13).

FIGURE 13: Some of the propagated seedlings within established nurseries hardened

From the figure 13 above, (a) *Dorstenia arachniformis*, (b) *Croton megalocarpus*, (c) *Fuerstia africana*, (d) *Maytenus putterlickoides*, and (f) *Terminalia brownii*.

A total of 1424 tree seedlings including 296 *C. tomentosa*, 155 *M. putterlickoides*, 103 *D. arachniformis*, 197 *T. brownii* and 253 *F. africana* were propagated and transferred to the wild to boost the in-situ populations within the 6 study sites. Some of the other medicinal plants transplanted included 207 *Croton megalocarpus*, 193 *Moringa oleifera*, and 20 *Aloe secundiflora*. An addition of 12 species (86 individuals) of rare local medicinal plants were planted in the medicinal plant garden for education and demonstration purposes.

4.6 Restoration of the Propagated Medicinal Plant Species

We conducted a site survey to identify suitable areas to transplant the raised seedlings within the target sites. The criteria for selecting the sites involved areas with minimal disturbance and suitable soil conditions. Local community members were mobilized to undertake restoration exercise at the designated sites (Figures 14 &15).

FIGURE 14: Restoration exercises within the study sites. From the photo, (a) locals in Kiou hill, (b) some of the locals in Nzaui hill and (c) locals of Kenze hill within Makueni and Mukaa subcounties.

FIGURE 15: Other restoration activities with locals within the study sites

To minimize seedlings watering, the planting exercise was carried out on the onset of rains. Similarly, we transferred, together with the locals, some of the seedlings to the established medicinal plant garden for the purposes of education and demonstration purposes (Figure 16). Apart from the targeted medicinal species, the medicinal species, the medicinal plant garden was stocked with other local priority medicinal plant species such as *Aloe* sp which have gained great prominence within the study area. We also encouraged the local community members to domesticate some of the medicinal plant species to minimize their decreasing populations.

FIGURE 16: *Ex-situ* conservation within the established medicinal plant garden

4.7 Creation of Awareness on the Conservation of Medicinal Plants and Other Species

Four workshops were held to raise conservation awareness and sensitize the local community members on the importance of conserving biodiversity. These awareness workshops and seminars were conducted in different areas of both Mukaa and Makueni sub-counties in Makueni county. The local members who were trained were awarded with certificates to signify their participation in training and as an encouragement to train others (Figure 17)

FIGURE 17: A group photo after a training and awareness meeting

After gathering substantial information from field and local traditional medicine practitioners to serve as evidence of the potential of the remnant dryland hilltop forests, two workshops were conducted in every site. These workshops were used to demonstrate the great medicinal value or potential of the hills. The results of the findings, including threat profile for the medicinal plants, were highlighted during the seminars (Figure18).

FIGURE 18: A stakeholder meeting on the medicinal potential of the study sites.

Over 200 locals were sensitized on the importance of conserving biodiversity including the five target medicinal plant species. Sustainable ways or approaches of harvesting medicinal plants were encouraged among the traditional medicine practitioners included harvesting part of the plant instead of the whole plant. Although traditional medicine is becoming increasingly unpopular among the youth, environmental/ biodiversity conservation was encouraged amongst them as they contribute to habitat destruction and degradation within the study area.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

The various remnant isolated hilltop forests within the arid and semi-arid areas of Makueni county are endowed with rich diversity of medicinal plant species. Unaware of the great potential of medicinal plant species, the local communities continue to degrade the habitats in which these plants thrive largely because of lack of awareness. Botanical information, especially medicinal plants in these sites is limited or lacking thus scarce evidence for more research and or studies.

Therefore, this project contributed to bridging this gap by availing additional evidence of 139 medicinal plant species distributed in six isolated dryland hilltop forests within Mukaa and Makueni sub counties. A breakdown of this reveals one critically endangered, three vulnerable, one endangered plant species listed in the International Union for Conservation of Nature (IUCN) Red list of threatened species. Similarly, several others are locally threatened, with some even protected under Appendix II of the Convention on International Trade in Endangered Species (CITES). Kiou hill and Matooi hill in Mukaa and Makueni subcounties are the richest in terms of medicinal plants as compared to Kenze, Nzaui, Nzueni, and Kwa Matheka hills. Matooi and Nzaui host the greatest number of Species of Conservation Concern (SCC). While Nzaui is gazetted and continues to be protected by the Kenya Forest Service (KFS), Matooi, Nzueni, Kenze and Kwa Matheka remain largely unprotected.

Therefore, based on the above evidence, this study recommends as follows: -

1. Given the limited funding, these isolated sites should be prioritized for conservation at both local and national levels; with what resources are available.
2. More studies should be done on *Dorstenia arachniformis* as less than five sub-populations are known to exist with two of them feared non-existent because of habitat loss and infrastructural development.
3. More studies should be done on the sites to include both plants and animals as this will generate a comprehensive checklist of local biodiversity for conservation actions.
4. Enhancement of community awareness within the study sites on the importance of conserving biodiversity and sustainable utilization of natural resources.

REFERENCES

Alam, G., & Belt, J. (2009). Developing a medicinal plant value chain: Lessons from an initiative to cultivate Kutki (Picrorhiza kurrooa) in Northern India. *The Journal of Infection in Developing Countries*.

Ali, A., & Businge, M. (2011). Biodiversity Chapter 4. *National Environment Management Authority*, Nairobi, Kenya.

Ayyad, M. A. (2003). Case studies in the conservation of biodiversity: degradation and threats. *Journal of Arid Environments*, *54*(1), 165-182.

Azaizeh, H., Fulder, S., Khalil, K., & Said, O. (2003). Ethnobotanical knowledge of local Arab practitioners in the Middle Eastern region. *Fitoterapia*, *74*(1-2), 98-108.

Bagine, R. (2006). Natural resource for sustainable development: Empowering local communities for biodiversity conservation. In *Proceedings of national museums of Kenya first scientific conference, 15th-17th Nov 2006* (pp. 18-20).

Bannerman, R. H., Burton, J., & Wen-Chieh, C. (1983). Traditional medicine and health care coverage; a reader for health administrators and practitioners.

Bayle, G. K. (2019). Ecological and social impacts of eucalyptus tree plantation on the environment. *Journal of Biodiversity Conservation and Bioresource Management*, *5*(1), 93-104.

Borris, R. P. (1996). Natural products research: perspectives from a major pharmaceutical company. *Journal of ethnopharmacology*, *51*(1-3), 29-38.

Chirchir, J.; Mungai, G. and Kariuki, P. (2006). Indigenous knowledge and conservation of natural resources: Resource medicinal plants utilisation in Eastern Africa. Proceedings of national museums of Kenya first scientific conference, 15th -17th Nov 2006; pp. 106- 111.

Duchelle, A. E. (2007). Observations on natural resource use and conservation by the Shuar in Ecuador's Cordillera del Condor. *Ethnobotany Research and Applications*, *5*, 005-023.

Grace, O. M., Malombe, I. T. A. M. B. O., Davis, S. D., Pearce, T. R., & Simmonds, M. S. J. (2010). Identifying priority species in dryland Kenya for conservation in the Millennium Seed Bank Project. *Systematics and conservation of African plants*, 749-758.

Hamilton, A. (2003). Medicinal plants and conservation: issues and approaches. *International Plants Conservation Unit, WWF-UK*, *51*.

Hamilton, A. (2009). Medicinal plant extinction 'a quiet disaster'. *New scientist*.

Hishe, M., Asfaw, Z., & Giday, M. (2016). Review on value chain analysis of medicinal plants and the associated challenges. *Journal of Medicinal Plants Studies*, *4*(3), 45-55.

Hoogar, R., Malakannavar, S., & Sujatha, H. T. (2019). Impact of *Eucalyptus* plantations on ground water and soil ecosystem in dry regions. *Journal of Pharmacognosy and Phytochemistry*, *8*(4), 2929-2933.

Islam, S., & Rahman, M. M. (2020). Allelopathic effects of *Eucalyptus camaldulensis* on germination and seedling growth of mungbean. *Journal of Bioscience and Agriculture Research*, *23*(01), 1894-1900.

Kamatenesi, M. M., Acipa, A., & Oryem-Origa, H. (2011). Medicinal plants of Otwal and Ngai sub counties in Oyam district, Northern Uganda. *Journal of Ethnobiology and Ethnomedicine*, *7*, 1-14.

Kassaye, K. D., Amberbir, A., Getachew, B., & Mussema, Y. (2006). A historical overview of traditional medicine practices and policy in Ethiopia. *Ethiopian Journal of Health Development*, *20*(2), 127-134.

Kipkore, W., Wanjohi, B., Rono, H., & Kigen, G. (2014). A study of the medicinal plants used by the Marakwet Community in Kenya. *Journal of ethnobiology and ethnomedicine*, *10*(1), 1-22.

Kisangau, D. P., & Herrmann, T. M. (2007). Utilization and conservation of medicinal plants used for primary health care in Makueni district, Kenya. *The International Journal of Biodiversity Science and Management*, *3*(3), 184-192.

Lipp, F. J. (1989). Methods for ethnopharmacological field work. *Journal of Ethnopharmacology*, *25*(2), 139-150.

Malombe, I., Matheka, K. W., Mwadime, T., & Mwachala, G. (2020). *Dorstenia arachniformis* (Moraceae), a new species from *Combretum* wooded grasslands in Makueni County, Kenya. *Phytotaxa*, *468*(2), 226-230.

Malonza, P.K., Atubwa, H, Munywoki, J. M (2023). *Survey of herpetofauna in selected Afromontane Hills of Makueni County in south-eastern Kenya*. A Technical Report Submitted to Nature Kenya, Nairobi.

McCorkle, M. C., Rangnekar, V. D., & Mathias-Mundy, E. (1997, November). Introduction: whence and whither ER&D. In *Ethnoveterinary Medicine: alternatives for livestock development. Proceedings of an International Conference held in Pune, India* (Vol. 1).

Moshi, M. J., Otieno, D. F., Mbabazi, P. K., & Weisheit, A. (2010). Ethnomedicine of the Kagera Region, northwestern Tanzania. Part 2: The medicinal plants used in Katoro Ward, Bukoba district. *Journal of ethnobiology and ethnomedicine*, *6*(1), 1-5.

Munywoki J. M, Malombe. I, Kathambi. V & Munywoki G. N. (2021). Conservation of Threatened Plant Species in Makueni, Kenya, through Community Mobilization. Technical Report, East African Herbarium.

Okigbo, R. N., Eme, U. E., & Ogbogu, S. (2008). Biodiversity and conservation of medicinal and aromatic plants in Africa. *Biotechnology and Molecular Biology Reviews*, *3*(6), 127-134.

Sebsebe, D., Beentje, H., Cheek, M., & Friis, I. (2017). *Sub-saharan botanical collections: taxonomic research and impediments*. "Scientia Danica, series B, Biologica", 6.

Silberfein, M. (1984). Differential development in Machakos District, Kenya. *Life before the drought*, 101-123.

Steenkamp, V. (2003). Traditional herbal remedies used by South African women for gynaecological complaints. *Journal of ethnopharmacology*, *86*(1), 97-108.

Teall, E. K. (2014). Medicine and doctoring in ancient Mesopotamia. *Grand Valley Journal of History*, *3*(1), 2.

Teklehaymanot, T., & Giday, M. (2007). Ethnobotanical study of medicinal plants used by people in Zegie Peninsula, Northwestern Ethiopia. *Journal of ethnobiology and Ethnomedicine*, *3*(1), 1-11.

Vasisht, K., & Kumar, V. (2004). Compendium of medicinal and aromatic plants Africa. *Earth, environmental and marine sciences and technologies. Area Science Park, Trieste, Italy: ICS-UNIDO*.

Wezel, A., & Rath, T. (2002). Resource conservation strategies in agro-ecosystems of semi-arid West Africa. *Journal of Arid Environments*, *51*(3), 383-400.

WHO. (2003). Fact Sheet, Traditional Medicine, Geneva, May 2003.

Yapijakis, C. (2009). Hippocrates of Kos, the father of clinical medicine, and Asclepiades of Bithynia, the father of molecular medicine. *in vivo*, *23*(4), 507-514.

Yirga, G. (2010). Ethnobotanical study of medicinal plants in and around Alamata, Southern Tigray, Northern Ethiopia. *Curr Res J Biol Sci*, *2*(5), 338-344.

Young, T, P. (1984). *Kenya's Indigenous forests: status, threats, and prospects for conservation action.*

Zhou, Y., Liu, B., Mbuni, Y., Yan, X., Mwachala, G., Hu, G., & Wang, Q. (2017). Vascular flora of Kenya, based on the Flora of Tropical East Africa. *PhytoKeys*, (90), 113.

APPENDICES

Table 1: Tabular representation of target medicinal plant species at Nzueni hill

S/no	Scientific name	Family	Vernacular/ Common Name	GPS	Pop. Size	Habitat Description	Conservation notes
1	*Maytenus putterlickoides*	Celastraceae	Muthunthi	-1.82787 37.60780	8	Slightly rocky, steep, eroded terrain. Area covered by *Ocimum gratissimum* species and scanty *Acacia tortilis* shrubs	Given the hill is highly "misused", there is the need to increase the population of this important affected species which has been destroyed.
2	*Terminalia brownii*	Combretaceae	Muuku	-1.82788 37.60781	4	Found on the east slopes in an area slightly eroded with low vegetation cover	There is a very low population of this species, characterized by low recruitment rate, thus need for its urgent conservation.
3	*Capparis tomentosa*	Capparaceae	Kitandamboo	-1.82794 37.60782	8	Area characterized by erosion, low vegetation cover, due to overgrazing and logging. Also, area invaded by *Gnidia latifolia* species.	Only one species was found on this hill. This shows the dire need to increase the population of this affected yet important species in this area.

Remarks: *F. africana* and *D. arachniformis* were not found at the time of the botanical survey, the hill was dry and perhaps the reason why the target species could not be found. *D. arachniformis* depends highly on other woody species for shade.

Table 2: Other non-target medicinal plant species identified on Nzueni hill-co-ordinates

S/no	Scientific name	Family	Vernacular name	GPS	Medicinal use
1	*Acacia tortilis*	Fabaceae	Mwaa	-1.82838 37.60837	The stem bark is chewed to alleviate coughing
2	*Commiphora abyssinica*	Burseraceae	Kitungati	-1.82802 37.60832	The latex is used in treating lesions and toothache
3	*Carissa edulis*	Apocynaceae	Mukawa	-1.82830 37.60811	The decoction of the leaves and stem bark are used to treat diarrhea
4	*Balanites aegyptiaca*	Zygophyllaceae	Kilului	-1.82825 37.60798	Used to treat fever and malaria
5	*Acacia brevispica*	Leguminosae	Mukuswi	-1.82816 37.60817	The stem bark is chewed to treat sore throat and dry coughs
6	*Croton dichogamus*	Euphorbiaceae	Muthinia	-1.82795 37.60805	The leaves decoction is used to treat diarrhea
7	*Commiphora balensis*	Burseraceae	Itula	-1.82728 37.60829	The latex is used to treat boils and edema
8	*Ocimum gratissimum*	Lamiaceae	Mukandu	-1.82821 37.60830	The leaves are used to treat headache and used to prepare pesticides

9	*Millettia vatkei*	Fabaceae	Kitw'aa	-1.82731 37.61284	Used to treat wounds, boils, open wounds and general body weakness
10	*Pavetta teitana*	Rubiaceae	Muthongoi	-1.81847 37.60837	Used to treat urine retention, oral lesions as well as tooth sores (*Mutata*-Kamba) among children.
11	*Euphorbia friesiorum*	Euphorbiaceae	Musilia	-1.82830 37.60811	It is used to cure rashes on human skin and treat cow glands, toothaches, and mouth sores.

***SUMMARY AND REMARKS:** A total of 14 medicinal plant species were recorded from Nzueni hill. Families with the highest number of medicinal plant species in the area include - Fabaceae, Euphorbiaceae and Burseraceae. Apart from the three target medicinal plant species found on the hill, an additional eleven medicinal plant species were recorded from the area. Also, three medicinal plants species that are threated under the IUCN criteria (*Millettia vatkei*, *Pavetta teitana* and *Euphorbia friesiorum*) were also recorded from the hill.

Table 3: Tabular representation of target medicinal plant species at Kwa Matheka Forest

S/no	Scientific name	Family	Vernacular/ Common Name	GPS	Pop. Size	Habitat Description	Conservation Notes
1	*Maytenus putterckoides*	Celastraceae	Muthunthi	-1.819558 37.593439	4	Rocky, sloppy terrain which is slightly eroded	The population of this species is affected by over-grazing thus sensitization of local community is a suitable remedial action
				-1.819315 37.592508	3		
				-1.82137 37.58929	2		
2	*Terminalia brownii*	Combretaceae	Kiuuku/ Muuku	-1.82137 37.58929	8	Hilly dry area with less vegetation cover	The low population of this species is linked to seed dormancy. More research on alternative propagation methods are necessary to enhance the population of this species
3	*Capparis tomentosa*	Capparaceae	Kitandamboo	-1.82095 37.58985	1	Found on a forest edge adjacent a homestead	Under threat of human destructive activities such as clearance, and grazing.
4	*Fuerstia africana*	Lamiaceae	kalaku	-1.820717 37.593911	6	Found in a thick vegetation cover dominated by *Millettia vatkei* and *Commiphora* sp.	Under threat of selective logging of *Commiphora* sp in the area.

Table 4: Other non-target medicinal plant species found in Kwa Matheka forest

S/no	Scientific name	Family	Vernacular/ Common name	GPS	Medicinal use
1	*Millettia vatkei*	Fabaceae	Kitw'aa	-1.82072 37.59391	Used to treat open wounds and boils
				-1.82074 37.59395	
2	*Uvaria scheffleri*	Annonaceae	Kikukuma	-1.81932 37.59251	The roots decoction is used to treat diarrhea
				-1.82077 37.59390	
3	*Croton megalocarpus*	Euphorbiaceae	Muthulu	-1.81839 37.59251	The stem bark is used to treat coughing while roots decoction is used to treat diarrhea
4	*Commiphora baluensis*	Burseraceae	Itungu	-1.81956 37.59341	The latex is used to treat lesions and oedema
5	*Steganotaenia araliacea*	Apiaceae	Muvuavui	-1.81962 37.59347	It is used to treat diarrhea in both human beings and animals
				-1.81938 37.59253	
6	*Croton dichogamus*	Euphorbiaceae	Muthinia	-1.81931 37.59248	The decoction of the leaves is used to treat coughing
7	*Vitex payos*	Lamiaceae	Kimuu	-1.82091 37.59150	Used to boost appetite and treat stomach-ache
8	*Pappea capensis*	Pappea	Kiva, Mba-fruit	-1.82090 37.58985	Used to enhance libido
9	*Zanthoxylum chalybeum*	Rutaceae	Mukenea	-1.82159 37.59708	The stem bark decoction is used to treat malaria
10	*Ficus glumosa*	Moraceae	Kikelenzu	-1.821625 37.59339	The stem bark is used to treat diabetes and cancer
11	*Euphorbia friesiorum*	Euphorbiaceae	Musilia	-1.820951 37.59234	It is used to cure rashes on human skin and treat cow glands, toothaches, and mouth sores.

12	*Pavetta teitana*	Rubiaceae	Muthongoi	-1.820717 37.593229	Used to treat urine retention, oral lesions as well as tooth sores (*Mutata*-Kamba) among children.

***SUMMARY AND REMARKS:** A total of 16 medicinal plant species were recorded at Kwa Matheka hill forest, including 4 target medicinal plant species. Euphorbiaceae and Lamiaceae were the most dominant families. Among the target species, only *Dorstenia arachniformis* was not recorded. Interestingly, other threatened medicinal plant species under the IUCN criteria were recorded namely, *Millettia vatkei*, *Pavetta teitana* and *Euphorbia friesiorum*).

Table 5: Tabular representation of target medicinal plant species at Matooi hill

S/no	Scientific name	Family	Vernacular/ Common name	GPS	Pop. Size	Habitat Description	Conservation Notes
1	*Fuerstia africana*	Lamiaceae	kalaku	-1.827061 37.560673	2	Sub-population found thriving at the base of a bushy vegetation in rocky, steep terrain.	Most of these sub-populations are affected by grazing and dry conditions, thus decreasing the population. Public awareness and conservation are required.
				-1.83639 37.55513	1		
				-1.82811 37.55874	2		
				-1.81723 37.55737	1		
2	*Terminalia brownii*	Combretaceae	Muuku	-1.83775 37.55409	2	Found thriving on hilly rocky slopes of the mountain where there is slight soil erosion	The distribution of this species in this area seems stable hence less conservation needed.
				-1.81876 37.55617	3		
				-1.82722 37.55736	1		
				-1.82967 37.55647	1		
3	*Maytenus putterlickioides*	Celastraceae	Muthunthi	-1.83775 37.55409	2	Found growing on the low base of the hill, characterized by high erosion and low to no vegetation	Given that it is classified as an animal fodder, especially during the dry season, its conservation is crucial.
				-1.818536 37.55906	1		
				-1.8396667 37.5564778	4		

				-1.819131 37.559239	2		
				-1.81482778 37.5570722	1		
4	*Dorstenia arachniformis*	Moraceae	Ng'ondu ya Itumbi	-1.83686 37.56734	1	Found growing near a river under *Ficus* sp, adjacent a foot path.	Under threat of habitat loss through selective logging
				-1.83985 37.56165	1		
5	*Capparis tomentosa*	Capparaceae	Kitandamboo	-1.82690 37.56167	5	Found within heavily grazed area, with eroded soil	In need of conservation as threated by herbivory and soil erosion

Table 6: Other non-target medicinal plant species found at Matooi hill

S/no	Scientific name	Family	Vernacular/ Common name	GPS	Conservation Notes
1	*Croton dichogamus*	Euphorbiaceae	Muthinia	-1.82590 37.56166	The leaves are used to treat stomachache
2	*Carissa edulis*	Apocynaceae	Mukawa	-1.82581 37.56167	Used to treat arthritis and body pain
				-1.82561 37.56156	
3	*Uvaria scheffleri*	Annonaceae	Kikukuma/ Mukukuma	-1.82561 37.56156	The roots decoction is used to treat diarrhea
				-1.83278 37.55409	
				-1.828761 37.55617	
				-1.82881 37.55924	
4	*Plectranthus barbatus*	Lamiaceae	Muvou	-1.82775 37.55409	The leaves are chewed raw or boiled and taken to treat diarrhea

5	*Aloe* sp.	Asphodelaceae	Kiluma	-1.82812 37.55409	The sticky latex is used to treat acne, boils, and skin rashes
				-1.83568 37.55648	
				-1.81913 37.55924	
6	*Combretum molle*	Combretaceae	Kiama	-1.8259447 37.554794	The decoction of the stem bark is used to treat coughing and eye cataracts
7	*Cassia abbreviata*	Fabaceae	Mwela ndathe	-1.820945 37.55479	The powdered dry stem bark is orally administered to treat malaria and cleanse blood
8	*Millettia vatkei*	Fabaceae	Kitw'aa	-1.818761 37.55617	Used to treat wounds, boils, and open wounds
9	*Pavetta teitana*	Rubiaceae	Muthongoi	-1.82085 37.55479	It is used to treat fever and oral sores
10	*Ficus glumosa*	Moraceae	Kikelenzu	-1.81422 37.55737	It is used to treat diabetes and cancer
11	*Dalbergia melanoxylon*	Fabaceae	Muvingo	-1.83967 37.55648	Used to relieve body pain and treat stomach-ache upsets
12	*Balanites aegyptiaca*	Zygophyllaceae	Kilului	-1.82391 37.56075	Used to treat constipation and alleviate trapped wind
13	*Scutia myrtina*	Rhamnaceae	Kitumbuu	-1.82398 37.55724	The leaves are used to treat malaria
14	*Vangueria infausta*	Rubiaceae	Kikomoa	-1.81913 37.55924	The decoction of the leaves is used to treat stomach-ache
15	*Euphorbia friesiorum*	Euphorbiaceae	Musilia	-1.83067 37.5565	It is used to cure rashes on human skin and treat cow glands, toothaches, and mouth sores.
16	*Acacia nilotica*	Fabaceae	Kisemei	-1.83157 37.55661	The pods are used to treat cancer and oedema
17	*Launaea cornuta*	Asteracea	uthunga	-1.83873 37.56559	The latex used to alleviate tooth ache
18	*Euclea divinorum*	Ebenaceae	Mukinyai	-1.82585 37.56214	Stembark is used to treat Snakebite

19	*Senna siamea*	Fabaceae	Mukengeta	-1.82591 37.56231	Leaves and roots are used to treat snakebite
20	*Securidaca longipedunculata* Fresen	Polygalaceae	Muuka	-1.82530 37.56183	Bulbs are used to treat seizures, mental problems and used in spiritual cleansing
21	*Searsia natalensis*	Anacardiaceae	Kitheu	-1.82536 37.56227	Decoctions of stem bark and leaves are used to treat urinary tract infections (UTIs)
22	*Barleria eranthemoides*	Acanthaceae	Thangila	-1.82566 37.56246	Decoctions of the stem bark are used to treat ulcers
23	*Bidens pilosa*	Astaraceae	Munzee	-1.82529 37.56183	Whole plant is used in blood cleansing
24	*Kigelia africana*	Bignoniaceae	kiatine	-1.82559 37.56177	The decoction from the stem bark was used to treat diarrhea
25	*Adenia gummifera*	Passifloraceae	Musoka	-1.82584 37.56195	The fruit is used to treat oedema
26	*Flueggea virosa*	Phyllanthaceae	mukuluu	-1.82526 37.56177	Leaves and stem decoctions are used to treat inflammatory bowel disorder
27	*Sclerocarya birrea*	Anacardiaceae	Kiua	-1.82547 37.56257	Stem bark and leaves concoction are administered to treat high blood pressure
28	*Secamone punctulata*	Apocynaceae	Mulali	-1.82570 37.56216	Its dry powder is used in spiritual cleansing
29	*Gynandropsis gynandra*	Cleomaceae	Mwanzo	-1.82566 37.56261	Decoction of the leaves is used to treat malaria
30	*Commelina benghalensis*	Cleomaceae	Ukengesya	-1.82609 37.56119	The leaves infusion is used to alleviate tooth ache.

SUMMARY AND REMARKS: A total of 35 medicinal plant species were recorded from Matooi hill, including all the target species and four threatened medicinal plant species under the IUCN criteria. Among the families, Fabaceae was the dominant with the most species.

Table 7: Tabular rrepresentation of target medicinal plant species at Nzaui hill

S/no	Scientific name	Family	Vernacular/ Common Name	GPS	Pop. Size	Habitat Description	Conservation Notes
1	*Terminalia brownii*	Combretaceae	Kiuuku	-1.91061 37.54445	7	Found on the hill, occurring together with *Uvaria scheffleri*	The population of this species is low hence its increment is encouraged.
				-1.95917 37.54281	6		
2	*Fuerstia africana*	Lamiaceae	Kalaku	-1.90841 37.54400	1	They are found growing on shallow soil under the shade of a high tree along the road. Another sub-population was found along the flowing water stream from kwa Ileli water storage tank, which is the main water source to the locals adjacent to the hill	Grazing and adverse weather conditions are the main threats affecting the population of this species in the area.
				-1.89615 37.55065	3		
				-1.90689 37.55123	1		
				-1.83969 37.551047	2		
				-1.89026 37.54888	1		
				-1.83969 37.55105	1		
				-1.89587 37.54701	2		
3	*Dorstenia arachniformis*	Moraceae	Ng'ondu ya Kitumbi	-1.88989 37.55262	1	Population occurring near a road under a *Ficus glumosa*	Highly threatened by road expansion and logging of the *Ficus glumosa*, efforts to safeguard it may include relocation to safe areas.
4	*Capparis tomentosa*	Capparaceae	Kitandamboo	-1.913382 37.54616	5	Population encountered on base of rock	Though stable population, dry climatic conditions limit seed recruitment
5	*Maytenus putterlickioides*	Celastraceae	Muthunthi	-1.905490 37.545820	3	Alongside main road in an area with cattle tracks.	Prone to grazing by livestock
				-1.886055 37.549686	7		

				-1.91441 37.55063	4		
				-1.90892 37.54204	1		

Table 8: Other non-target medicinal plant species identified at Nzaui hill

S/no	Scientific Name	Family	Vernacular/ Common name	GPS	Medicinal Uses
1	*Aloe* sp.	Asphodelaceae	Kiluma	-1.91085 37.54501	It is used to treat skin ailments and other skin infections
2	*Carissa edulis*	Apocynaceae	Mukawa	-1.90158 37.54844	It is used to treat arthritis
				-1.90606 37.54773	
3	*Uvaria scheffleri*	Annonaceae	Mukukuma	-1.90889 37.54278	The roots are used in treating diarrhea
				-1.91386 37.54624	
4	*Combretum molle*	Combretaceae	Kiama	-1.91180 37.53971	The stem bark is used to treat coughing
5	*Pavetta teitana*	Rubiaceae	Muthongoi	-1.91458 37.54549	The leaves infusion is used to alleviate tooth ache
				-1.90969 37.54079	
6	*Vangueria infausta*	Rubiaceae	Kikomoa	-1.91165 37.54081	It is used to treat stomachache and diarrhea
7	*Dalbergia melanoxylon*	Fabaceae	Muvingo	-1.89284 37.54919	The decoction is used to treat pain and coughing
8	*Fagaropsis hildebrandtii*	Rutaceae	Muvindavindi	-1.912038 37.54079	Used to treat arthritis and tuberculosis

9	*Millettia vatkei*	Fabaceae	Kitw'aa	-1.91204 37.54646	Used to treat open wounds and boils
10	*Euphorbia friesiorum*	Euphorbiaceae	Musilia	-1.91712 37.54080	It is used to cure rashes on human skin and treat cow glands, toothaches, and mouth sores.

***SUMMARY AND REMARKS:** A total of 15 medicinal plant species were recorded in Nzaui hill, including all the target medicinal plant species. Also, other four threatened medicinal plant species under the IUCN criteria were identified and mapped in Nzaui hill. Fabaceae, Rubiaceae, Combretaceae were the most dominant families in Nzaui hill forest.

Table 9: Tabular representation of target medicinal plant species at Kenze hill

S/No	Scientific name	Family	Vernacular/ Common name	GPS	Pop. Size	Habitat Description	Conservation Notes
1	*Terminalia brownii*	Combretaceae	Kiuuku	-1.87850 37.33189	1	Found growing on slightly eroded area near a dry river stream with less vegetation	There is witnessed tree cutting and bush clearing, which have affected this species' population. Awareness is crucial to address the associated threat.
				-1.87245 37.33149	2		
				-1.87352 37.33306	1		
2	*Fuerstia africana*	Lamiaceae	Kalaku	-1.87372 37.33194	2	Found occurring as one sub-population under low vegetation of *Lantanna camara* at the most hilltop	Adverse weather and cattle grazing are a threat to this species
				-1.87245 37.33521	1		
3	*Maytenus putterlickioides*	Celastraceae	Muthunthi	-1.87725 37.33136	3	Found along the roadside thriving on a steep rocky terrain dominated by slight	Cattle grazing has affected the population of these species; thus, awareness creation is important
				-1.87421 37.33147	4		

				-1.87352 37.33306	2	erosion	
				-1.87244 37.33521	3		
				-1.87349 37.33906	1		
				-1.87400 37.33902	1		
				-1.87402 37.34044	3		
				-1.87456 37.34219	1		
4	*Capparis tomentosa*	Capparaceae	Kitandamboo	-1.86729 37.34255	3	This population was found near a round junction, with scattered trees on a dry area	Road expansion and the dry climatic conditions of the area threaten these individuals. Similarly, they are prone to being grazed by passing animals

Table 10: Other non-target medicinal plant species identified in Kenze hill

S/no	Scientific name	Family	Vernacular/ Common name	GPS	Medicinal use
1	*Euclea divinorum*	Ebenaceae	Mukinyai	-1.87886 37.33206	Roots are used as anthelmintic for both people and animals.
2	*Ximenia americana*	Olacaceae	Kitula	-1.87886 37.33215	Roots decoction is used to treat malaria
3	*Uvaria scheffleri*	Annonaceae	Mukukuma	-1.87887 37.33207	The leaves are used to treat stomach-ache
4	*Carrisa edulis*	Apocynaceae	Mukawa	-1.87878 37.33211	The roots and leaves are used to treat arthritis
				-1.87850 37.33189	

				-1.87812 37.33145	
5	*Osyris lanceolata*	Santalaceae	Muthaaw'a	-1.87850 37.33189	The leaves are chewed to treat stomach-ache
6	*Combretum molle*	Combretaceae	Kiama Muama	-1.87854 37.33192	The decoction of the stem bark is used to treat jaundice
7	*Rhus natalensis*	Anacardiaceae	Kitheu Mutheu	-1.87860 37.33184	The leaves are chewed to alleviate diarrhea and roots used as a detoxifier
8	*Aloe* sp.	Liliaceae	Kiluma	-1.87887 37.33206	It is used to treat skin ailments and malaria
9	*Ximenia caffra*	Rubiaceae	Kitula Mutula	-1.87858 37.33143	The fruits are edible and used to treat mouth sores and cough
10	*Plectranthus* sp.	Lamiaceae	Kiyo	-1.87332 37.33506	Used to treat headache
11	*Actinopteris semiflabellata*	Pteridaceae	Mwei-wa –ivia	-1.87144 37.33145	The whole plant is used as anaphrodisiac agent
12	*Punica granatum*	Lythraceae	Kukumanga	-1.87522 37.33148	The roots are used to treat malaria
13	*Zanha africana*	Sapindaceae	Kikolekya Mukolekyia	-1.87850 37.33189 -1.87886 37.33206	The decoction of the stem bark is used to alleviate pain
14	*Commiphora habessinica*	Burseraceae	Itungati Kitungati	-1.87352 37.33306	The latex is used to treat lesions

***SUMMARY AND REMARKS:** A total of 18 medicinal plant species were recorded at Kenze hill, including four of the target medicinal plant species. Different family species were mapped from this site. None of the recoded medicinal plant species were in the IUCN Red List of threatened plants species, however, several such as the *Osyris lanceolata* were protected for trade under the CITES.

Table 11: Tabular representation of target medicinal plant species at Kiou hill

S/no	Scientific Name	Family	Vernacular/ Common Name	GPS	Pop. Size	Habitat Description	Conservation Notes
1	*Terminalia brownii*	Combretaceae	Kiuuku/ Muuku	-1.93099 37.32156	1	Found on steep rocky terrain with minimal erosion	There is dire urge to restore the declining population of this species in this area
				-1.93088 37.32143	2		
				-1.92991 37.33747	1		
				-1.91856 37.34246	1		
2	*Capparis tomentosa*	Capparaceae	Kitandamboo	-1.91540 37.34214	4	Found along the road and river barks thriving on loam-sandy soils	Threatened by land clearing for farming purposes and the leaves being used as animal feed. Conservation to restore the declining population is needed
				-1.91870 37.34214	2		
				-1.93925 37.32288	1		
3	*Fuerstia africana*	Lamiaceae	Kalaku	-1.93911 37.34420	3	Thriving on rocky areas covered by invasive species (*Lantanna camara*)	This species is found occurring in very low number hence the need for its increment
				-1.93906 37.34424	2		
4	*Maytenus putterlickioides*	Celastraceae	Muthunthi	-1.93899 37.31167	1	Growing on slightly eroded rocky area	These species is used as animal feed leading to its damage, thus posing a threat hence the need for public awareness
				-1.94003 37.324435	3		
				-1.94040 37.32357	2		
				-1.93790 37.34415	1		
				-1.93891 37.31172	2		

Table 12: Other non-target medicinal plant species identified at Kiou hill

S/no	Scientific Name	Family	Vernacular/ Common name	GPS	Medicinal Use
1	*Carrisa edulis*	Dogbane	Mukawa	-1.93121 37.32142	The roots and leaves are used to treat diarrhea in both human and animals
				-1.93319 37.32138	
2	*Osyris lanceolata*	Santalaceae	Muthaaw'a	-1.93129 37.32143	The decoction is used to treat diarrhea. The plant is also used in the preparation of dye and perfumes.
				-1.93134 37.34112	
3	*Combretum molle*	Combretaceae	Kiama	-1.92099 37.32152	Leaves decoction is used to treat jaundice and eye cataracts
				-1.94035 37.32013	
				-1.93921 37.31958	
4	*Uvaria scheffleri*	Annonaceae	Mukukuma	-1.93947 37.32378	Powdered stem bark is used to treat diarrhea
				-1.93932 37.32138	
5	*Aloe* sp.	Liliaceae	Kiluma	-1.93065 37.32157	It is used to treat skin ailments and malaria
				-1.93788 37.32187	
				-1.94015 37.32782	
6	*Ximenia caffra*	Rubiaceae	Kitula	-1.930482 37.321425	The fruits are edible and are used to treat mouth sores and cough
7	*Plectranthus* sp.	Lamiaceae	Kiyo	-1.93305 37.32143	The leaves are rubbed on the head sides to treat headache and seizure

8	*Croton megalocarpus*	Euphorbiaceae	Muthulu	-1.93561 37.32048 -1.94417 37.32868	The stem bark is used to treat dry coughs while the decoction of the roots treats diarrhea
9	*Zanha africana*	Sapindaceae	Kikolekya	-1.94009 37.32485	Roots are used to end dizziness and treat syphilis
10	*Strychnos henningsii*	Loganiaceae	Muteta	-1.941757 37.314947	It is used as a food additive and treats stomach-ache
	Actinopteris semiflabellata	Pteridaceae	Mwei-wa-ivia	-1.94852 37.32236	The whole plant is used as an anaphrodisiac agent
11	*Lannea schweinfurthii*	Anacardiaceae	Kyuasi	-1.94113 37.32512 -1.94054 37.32548	The stem bark is used to alleviate coughing and as a blood cleanser
12	*Acacia nilotica*	Leguminoseae	Kisemei	-1.93944 37.32402	The stem bark is used to treat cough and stomach-ache
13	*Vangueria madagascariensis*	Rubiaceae	Kikomoa	-1.93884 37.32611 -1.93112 37.32132	Used to eliminate parasitic worms
14	*Pappea capensis*	Sapindaceae	Kiva	-1.92300 37.31470	It is used to treat syphilis and other sexually transmitted diseases
15	*Grewia bicolor*	Malvaceae	Mulawa Kikalawa	-1.937579 37.332966	Its milky latex is used to treat smallpox
16	*Acokanthera schimperi*	Apocynaceae	Muvai	-1.933299 37.323590	The decoction of leaves is used as a pesticide
17	*Scutia myrtina*	Rhamnaceae	Kitumbuu	-1.93195 37.33056	It is used to treat malaria
18	*Senna lingaracemosa*	Fabaceae	Munyunga mai	-1.93288 37.32932	Boiled leaves are used to treat mouth sores

19	*Acacia tortilis*	Fabaceae	Mwaa	-1.91987 37.31771	The bark is used to alleviate coughing
20	*Balanites aegyptiaca*	Zygophyllaceae	Kilului	-1.93137 37.31889	The stem bark is used to treat pain
21	*Ocimum suave*	Lamiaceae	Mukandu	-1.93471 37.31946	Used to alleviate coughing and pain
22	*Clerodendrum eriophyllum*	Verbenaceae	Muumba	-1.93372 37.32634	The leaves are used to treat boils and inflammation
23	*Ficus sycomorus*	Moraceae	Mukuyu	-1.92520 37.32000	Used to alleviate toothache
24	*Withania somnifera*	Solanaceae	Mwanzo	-1.92816 37.31408	Used to treat boils and other sexually transmitted infections (STIs)
25	*Solanum incanum*	Solanaceae	Mutongu	-1.93303 37.31807	Used to treat stomach-ache and ear infections
26	*Ocimum americanum*	Solanaceae	Mutaa	-1.93464 37.32664	The leaves are used to treat headache and hiccups
27	*Zanthoxylum chalybeum*	Rutaceae	Mukenea	-1.92274 37.34143	Used to treat coughing and malaria
				-1.92338 37.34056	
				-1.90921 37.33704	
28	*Asparagus setaceus*	Asparagaceae	Uusya	-1.90924 37.33705	Used to treat foot fungal disease
29	*Ormocarpum kirkii*	Fabaceae	Muema nzou	-1.9092 37.33708	Used to treat oral sores
30	*Solanecio angulatus*	Asteraceae	Kitanyuka mwene	-1.93125 37.32142	It is used to treat mouth sores
31	*Erythrina abyssinica*	Fabaceae	Muvuti	-1.924001 37.330421	Roots and leaves are used to treat hiccups
32	*Plectranthus comosus* Sims	Lamiaceae	Mwoya	-1.93983 37.32384	Decoction is used to treat obesity

33	*Actinopteris semiflabellata*	Pteridaceae	Mwei-wa-ivia	-1.94057 37.32610	Used to treat ulcers and stomach upset
34	*Adenia gummifera*	Passifloraceae	Musoka	-1.93932 37.32566	Decoction is used to initiate weight loss
35	*Plumbago zeylanica*	Plumbaginaceae	Mung'atha	-1.94004 37.32627	Used to treat oedema
36	*Kleinia squarrosa*	Asteraceae	Mung'endya nthenge	-1.93871 37.32627	Leaves' decoction is used to alleviate stomach pain
37	*Ricinus communis*	Euphorbiaceae	mbaiki Mbaiki	-1.93856 37.32624	The stem bark is used to treat gonorrhoea and other STIs

***SUMMARY AND REMARKS:** A total of 41 medicinal plant species were recorded from Kiou hill, including four which were targeted by the study. The Fabaceae family was the most dominant with the majority of the recorded medicinal plant species. None of the recoded medicinal plant species were in the IUCN RedList of threatened plants species, however, several such as the *Osyris lanceolata* were protected for trade under the CITES.

Dorstenia arachniformis Matheka, Malombe, T. Mwadime & Mwachala

Taxonomy and Nomenclature

This species belongs to the *Dorstenia* genus in Moraceae family.
It is locally known as Ngondu ya Itumbi

Description

Dorstenia arachniformis is an erect perennial herb that can grow as high as 80cm. Its stem is succulent and has a rhizomatous tuber. Its flower is triangular in shape.

Habitat and Distribution

It thrives in shallow humic clay-sand soils in shallow river barks and rock crevices within *Combretum* and *Acacia* vegetation at elevation of between 1250-1400 m above the sea level. It is only known from one locality (Wote) within Makueni subcounty.

Medicinal use

In the Kamba community, it is mostly used in spiritual cleansing and performing traditional rituals.

Propagation

It can be propagated vegetatively through cuttings. Regeneration of new species can be from the leaves. Leaves are soaked in a growth hormone and planted in seedling pots and kept under regulated temperatures to enhance root development.

Threat

This species is critically endangered based on IUCN criteria. Habitat destruction to pave way for agricultural activities and also overharvesting for medicinal use are some of the threats to this species. Drought conditions also affect this species within its habitat.

Reference

Malombe, I., Matheka, K. W., Mwadime, T., & Mwachala, G. (2020). *Dorstenia arachniformis* (Moraceae), a new species from *Combretum* wooded grasslands in Makueni County, Kenya. *Phytotaxa*, *468*(2), 226-230.

FIGURE 19: *Dorstenia arachniformis* Leaflet

Terminalia brownii Fresen

Taxonomy and Nomenclature

This species belongs to the genus *Terminalia* in Combretaceae family.

It is locally known as Muuku/Kiuuku (Kamba).

Description

Terminalia brownii is a leafy deciduous plant with a rounded spreading crown and can grow as high as 25m. It bears winged fruits that are smooth and greenish when young, turning purple-red to brown on maturity (Orwa *et al.,* 2009).

Habitat and distribution

This species occurs in bushlands, and wooded savannah within arid and semi-arid areas. It is usually found along rivers in very dry areas. It is a drought resistant, mostly distributed in arid and semi-arid areas in Kenya.

Medicinal uses

Its stem bark is used to treat yellow fever, diabetes and it has immuno-modulatory effect (Alema *et al.,* 2020; Mbiri *et al.,* 2023). Leaves decoction used to treat eye problems, diarrhea, stomachache, fungal infections, diarrhea and as an anti-helminthic (Salih *et al.,* 2017)). The root is used to treat allergy reactions. Bark and leaves decoctions are used as de-wormers in livestock. Both stem and root extracts are used as antibacterial (Mwambo *et al.,* 2007).

Propagation

It is usually propagated from seeds as well as cuttings.

Threat

An increase in the demand for fuel, construction materials, fencing post has threatened this species. Seed dormancy is a major drawback leading to low germination rates.

References

1. Salih, E. Y., Fyhrquist, P., Abdalla, A. M., Abdelgadir, A. Y., Kanninen, M., Sipi, Luukkanen, O., Fahmi M.K. M., Elamin, M.H., Ali, H. A. (2017). LC-MS/MS tandem mass spectrometry for analysis of phenolic compounds and pentacyclic triterpenes in antifungal extracts of *Terminalia brownii* (Fresen). *Antibiotics*, *6*(4), 37.
2. Alema, N. M., Periasamy, G., Sibhat, G. G., Tekulu, G. H., Hiben, M. G. (2020). Antidiabetic activity of extracts of *Terminalia brownii* Fresen. Stem bark in mice. *Journal of experimental pharmacology*, 61-71.
3. Mbiri, J. W., Ogila, K., Kisangau, P., Gicheru, M. (2023). Terminalia brownii Fresen: stem bark dichloromethane extract alleviates pyrogallol-induced suppression of innate immune responses in swiss albino mice. *Evidence-Based Complementary and Alternative Medicine*, *2023*.
4. Mwambo, Z. H., Moshi, M. J., Masimba, P. J., Kapingu, M. C., Nondo, R. S. (2007). Antimicrobial activity and brine shrimp toxicity of extracts of *Terminalia brownii* roots and stem. *BMC complementary and Alternative Medicine*, *7*, 1-5.
5. Orwa C, A Mutua, Kindt R, Jamnadass R, S Anthony. 2009 Agroforestry Database: a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp)

FIGURE 20: *Terminalia brownii* Leaflet

Terminalia brownii Fresen

Taxonomy and Nomenclature

This species belongs to the genus *Terminalia* in Combretaceae family.

It is locally known as Muuku/Kiuuku (Kamba).

Description

Terminalia brownii is a leafy deciduous plant with a rounded spreading crown and can grow as high as 25m. It bears winged fruits that are smooth and greenish when young, turning purple-red to brown on maturity (Orwa *et al.,* 2009).

Habitat and distribution

This species occurs in bushlands, and wooded savannah within arid and semi-arid areas. It is usually found along rivers in very dry areas. It is a drought resistant, mostly distributed in arid and semi-arid areas in Kenya.

Medicinal uses

Its stem bark is used to treat yellow fever, diabetes and it has immuno-modulatory effect (Alema *et al.,* 2020; Mbiri *et al.,* 2023). Leaves decoction used to treat eye problems, diarrhea, stomachache, fungal infections, diarrhea and as an anti-helminthic (Salih *et al.,* 2017)). The root is used to treat allergy reactions. Bark and leaves decoctions are used as de-wormers in livestock. Both stem and root extracts are used as antibacterial (Mwambo *et al.,* 2007).

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It is usually propagated from seeds as well as cuttings.

Threat

An increase in the demand for fuel, construction materials, fencing post has threatened this species. Seed dormancy is a major drawback leading to low germination rates.

References

1. Salih, E. Y., Fyhrquist, P., Abdalla, A. M., Abdelgadir, A. Y., Kanninen, M., Sipi, Luukkanen, O., Fahmi M.K. M., Elamin, M.H., Ali, H. A. (2017). LC-MS/MS tandem mass spectrometry for analysis of phenolic compounds and pentacyclic triterpenes in antifungal extracts of *Terminalia brownii* (Fresen). *Antibiotics*, *6*(4), 37.
2. Alema, N. M., Periasamy, G., Sibhat, G. G., Tekulu, G. H., Hiben, M. G. (2020). Antidiabetic activity of extracts of *Terminalia brownii* Fresen. Stem bark in mice. *Journal of experimental pharmacology*, 61-71.
3. Mbiri, J. W., Ogila, K., Kisangau, P., Gicheru, M. (2023). Terminalia brownii Fresen: stem bark dichloromethane extract alleviates pyrogallol-induced suppression of innate immune responses in swiss albino mice. *Evidence-Based Complementary and Alternative Medicine*, *2023*.
4. Mwambo, Z. H., Moshi, M. J., Masimba, P. J., Kapingu, M. C., Nondo, R. S. (2007). Antimicrobial activity and brine shrimp toxicity of extracts of *Terminalia brownii* roots and stem. *BMC complementary and Alternative Medicine*, *7*, 1-5.
5. Orwa C, A Mutua, Kindt R, Jamnadass R, S Anthony. 2009 Agroforestry Database: a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp)

FIGURE 21: *Fuerstia africana* Leaflet

Capparis tomentosa Lam.

Taxonomy and Nomenclature

This species belongs to the genus *Capparis* of Capparaceae family. It is locally known as Kitandamboo (Kamba).

Description

This species is deciduous, spiny and varies in habit. It is usually much-branched shrub or small tree with scrambling or climbing branches. Sometimes erect upto 3m in height. It produces pendulous fruits with pink to bright orange coloration when ripe.

Habitat and Distribution

It thrives in deep loam soils along the river banks, hill slopes, arid sandy plains and coastal regions. It is native to Eastern and Southern parts of Africa.

Medicinal uses

The roots are used to treat sexual diseases and other sex related disorders such as female sterility, syphilis, gonorrhea, male dysfunction, mental illness, including malaria, asthma, inflammation, and evil eyes (Gebrehiwot *et al.,* 2019). It is also believed to boost $CD4^+$ count in HIV/AIDS patients. The root powder is used to treat snake bite and dressing wounds. Decoctions from leaves and stem bark is used to alleviate fever, dry coughs and asthma. The smoke of burnt stem bark is used to treat bronchitis, headaches and chest pains. All medicinal preparations of this species are dispensed with caution since it is poisonous.

Propagation

It is usually propagated through seeds and vegetatively by cuttings.

Threat

This species is found thriving in small areas, which are prone to be cleared due to the increasing demand to create more areas for agriculture and settlement for increasing human population. Similarly, it is destroyed through herbivory by animals.

References

1. Gebrehiwot, S., Giday, M., Erko, B., Mekonnen, Y. (2019). In vivo Antimalarial Activity of *Capparis tomentosa* Lam. in Mice Infected with *Plasmodium berghei*. *Journal of Ayurvedic and Herbal Medicine*, *5*(2), 44-48.

FIGURE 22: *Capparis tomentosa* Leaflet

Maytenus putterlickoides loes (A. Rich)

Taxonomy and Nomenclature

This species belongs to the *Maytenus* genus of the Celastraceae family. It is locally known as Muthunthi (Kamba).

Description

Maytenus putterlickoides is a deciduous shrub with thorny stem and grows upto 2 m high.

Habitat and Distribution

It is often found thriving in deep loam soils or rocky terrain on hills at an elevation of 300-1800 m above sea level.

Medicinal Use

The leaves of this species are used to treat stomachache and other gastrointestinal disorders. Its roots have been found useful in the treatment of leukemia (Schaneberg *et al.,*2001; Feng *at al.,* 2004). It is also used to treat malaria, leishmania and bacterial infections in Kenya (Kigondu *et al.,* 2009; Mugweru *et al.,* 2016).

Propagation

It is propagated from seeds and cuttings.

Threat

It is affected by bush clearing for agricultural activities as well as herbivory by animals.

References

1. Schaneberg, B. T., Green, D. K., & Sneden, A. T. Dihydroagarofuran Sesquiterpene Alkaloids from *Maytenus putterlickoides*. *Journal of natural products*, 2001,*64*(5), 624-626.
2. Feng, X., Gao, Z., Li, S., Jones, S. H., & Hecht, S. M. (2004). DNA Polymerase β Lyase Inhibitors from *Maytenus putterlickoides*. *Journal of natural products*, *67*(10), 1744-1747.
3. Kigondu, E. V., Rukunga, G. M., Keriko, J. M., Tonui, W. K., Gathirwa, J. W., Kirira, P. G., Ndiege, I. O. (2009). Anti-parasitic activity and cytotoxicity of selected medicinal plants from Kenya. *Journal of Ethnopharmacology*, *123*(3), 504-509.
4. Mugweru, F. G., Nyamai, D. W., Arika, M. W., Ngugi, M. P., Gathumbi, P. K. (2016). Antimicrobial activity of aqueous extracts of *Maytemus putterlickoides*, *Senna spectabilis* and *Olinia usambarensis* on selected diarrhea-causing bacteria,7 (*2*), 1-6.

***FIGURE 23: Maytenus putterlickoides* Leaflet**

Ethnobotanical Survey Form

1. **Location information:**

a) Name of the study site.

b) Location of study site.

Sub-county:Makueni

County: Makueni

2. **Species identification:**

a) Target medicinal species found on this site.

S/No	Scientific name	Family	Vernacular/ common name	GPS	Medicnal use

FIGURE 24: Ethnobotanical Surveys' form used to collect medicinal plants data

Questionnaires for Traditional Medicine Practitioners

Traditional Medicine Practitioner

Gender:

Age:

Duration of practice:

Education level:

Location (name &GPS)

Species used for medicinal drug preparations

Name of species			Parts used	Method of Preparation	Mode of administration	No. of patients treated
Scientific name	Family	Common/Vernacular name				

Interviewed by: Date:

FIGURE 25: Questionnaire used to capture plants used in traditional medicine preparation

FIGURE 26: A template of certificates issued to locals