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Medicinal plants and their economic value in Kakamega Forest Ecosystem: A case study of sustainable land/forest project in Western Kenya

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ABSTRACT

Forest Management of ecosystems plays a fundamental role in providing essential goods and services to rural communities. However, there has been a reduction in the natural forest cover due to resource utilization pressure. The pressure on forest resources is catalyzed by the expansion of markets for forest products, agricultural expansion and escalating poverty levels. An upsurge in the number of users of herbal medicine in urban and rural areas has increased the pressure on the forests, while modernization and change in lifestyle have led to the loss of traditional knowledge associated with medicinal plants utilization and conservation. No detailed economic evaluation of medicinal plants has been undertaken and the current illegal, unregulated and unreported exploitation of medicinal plants has led to overexploitation and loss of biodiversity. A better understanding of the abundance, distribution, uses and economic value of medicinal plants is important for the sustainable exploitation and conservation of forests. The study covered four forest blocks of Kakamega, North Nandi, South Nandi and Kibiri to determine plant species diversity, and their distribution in the disturbed and undisturbed areas of the forest; assess knowledge, utilization and economic estimate by willingness to-pay approach of medicinal plants to communities adjacent to the Kakamega Forest. Value chain analysis had been conducted for medicinal plants and forest user groups from Community Forest Association (CFA) had been trained in product development and access market were used in the study. Experimental Plot techniques were also used to gather ecological data on the frequency, density, diversity and distribution of the plants, whereas key informant interviews, focus group discussions and household interviews were utilized to gather information on ethnobotanical knowledge and household socioeconomic data. Thirty-two key species of medicinal plants were identified and used by local people around the Kakamega forest ecosystem. Forty-seven percent (47%) of these were trees, thirty four percent (34%) were shrubs, sixteen percent (16%) were herbs and climbers three percent (3%). Seventy percent (70%) of the medicinal plants were within the forest and thirty percent (30%) were outside the forest. The three most dominant families were *Euphorbiaceae*, *Piperaceae* and *Fabaceae* with leaves as the most common plant part used constituting 31 % (n=26) of the preparations, followed by roots with 20% (n=17),bark with 14% (n=14), fruits with 11 % (n=9), seeds having 11% (n=9), flowers 2% (n=2) and sap 2 % (n=3). The economic benefits generated from the medicinal plants within the forest ecosystem services in the Kakamega-Nandi landscape in terms of direct use value was about KES 601,918,256 (≈USD 5.19 million) per year, while indirect use value was KES 317,288,046 (≈USD 2.74 million) per year. Indigenous knowledge of the medicinal uses of the plants, their commercial aspects and distribution trends in the forest provision of wide scope for understanding relevant market systems may be tapped for decision support in rural health service planning, policy formulation for conserving the forest, tracking and mitigation of climate change impacts.

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INTRODUCTION

Sustainable land and forest management have great potential to restore biodiversity, reduce environmental degradation, and assist smallholder farmers to achieve food, water and income security. The forests worldwide cover close to 31% of the earth's land area, and about 240 million people live in and around these forest ecosystems (World Bank, 2003; FAO, 2010). In Africa, forest ecosystems contribute about 17% of the world's forest land size and they are the source of livelihood for the adjacent communities (Schippmann *et al.*, 2006). According to the United Nations, the world loses 4.7 million hectares of tropical forest every year while Kenya loses 12,000 hectares of forest each year. Despite all these threats, it is estimated that about 80% of the Asian and African population use traditional medicine and products derived from forests for their healthcare needs (Oyebode *et al.*, 2016). In Africa, some of these plants are an essential source of curative, preventive remedies for various ailments (Sindiga, 1995; Villena-Tejada *et al.*, 2021) and also for preventive therapy for human beings (Hassan, 2020). For decades, knowledge of medicinal plant species has existed in the majority of African cultures (Sindiga, 1995). In Uganda and Ethiopia, about 45 to 70 % of people are more likely to choose traditional medical care than conventional medicine (Tran *et al.*, 2016). In Kenya the rural areas depend on traditional medicine for their healthcare needs (Owuor & Kisangau, 2006; Kigen *et al.*, 2013) with plant medicine being practiced continuously long period (WHO, 2013). Furthermore in Kenya, 70% of the people use local homemade remedies as their first source of medicine, while more than 90% use plant related remedies at one time or another (Mbuni *et al.*, 2020). Currently the Government of Kenya has taken steps of facilitating the restoration of forest resources and increase the forest cover to 52,276.43 km^2 under forest representing 8.83% up from 6% (MEF, 2022) with close to 3.6% of Kenya's Gross Domestic Product being derived from forests through direct and indirect contribution to the local and national economies (Republic of Kenya, 2014). Hence the need to conserve the Kakamega forest which is known to be the easternmost fragment of Guinea – Congolean lowland rainforest belt, stretching from Kenya across Uganda, East and Central Africa to the West African coast (Wagner *et al.*, 2008). The Kakamega forest ecosystem is currently affected by agricultural encroachment which has led to large-scale degradation in recent years, characterized by illegal tree- felling and charcoal-burning firewood collection, forest grazing, and unsustainable harvesting practices like debarking trees. In Kakamega and Nandi forests, there is a very high demand for the forest products like firewood, grazing, herbal medicine, wild fruits, wild vegetables, bush meat, honey, charcoal, thatch grass and ecotourism. In addition, the current illegal, unregulated and unreported exploitation of medicinal plants may lead to overexploitation and loss of biodiversity with no detailed documentation of medicinal plants, their use and economic values. Hence the need for documentation of medicinal plants whose use has been growing in and the need to transform them into a commercial enterprise. This paper further presents the economic value of medicinal plants within the Kakamega forest as a way of demonstrating the linkage between conservation and sustainable utilization.

MATERIALS AND METHODS

Study Area

This study was done within four forest blocks and the adjacent communities living around the Kakamega forest ecosystem in Kenya. The area of ecosystems covered comprises three counties namely Kakamega, Vihiga and Nandi Counties in Kenya (Figure 1). Kakamega forest ecosystem covers a total area of 240 km^2 and holds about 450 species of trees, most of them indigenous. The ecosystem has dense indigenous forests covering 11,345 ha; semi-dense indigenous forest, cover 2,705 ha while plantations cover 832 ha, scattered trees, and glades cover 1,557 ha and cleared or cultivated areas cover 2,002 ha. At an average altitude of 1580m above sea level, the Kakamega forest receives more than 2000mm of rainfall per year. The mean temperature varies between 26-27^{o}C while at night it is 13^{o}C. The forest receives an average of 2080 mm of rain per year. Rainfall is bimodal with the heaviest fall in April and May (during the "long rains"), with a slightly drier June and a second peak of rain roughly in September to November (the "short rains"). January and February are the driest months. The forest hosts tree and shrub species of Congolean lowland forest affinities, including a number of endemic plant species, mostly ferns and orchids.

Design of Study

The study focused on four forest blocks of Kakamega, North Nandi, South Nandi and Kibiri to determine plant species diversity, and distribution; assess knowledge, utilization and economic estimate by willingness to-pay approach of medicinal plants to communities adjacent to the Kakamega Forest. The line transects were made with experimental plots done along each forest block to gather plant species data on frequency, density, diversity and distribution of the plants. The contingent valuation method (CVM) was applied to estimate local communities' willingness to pay (WTP) to support the conservation of Kakamega, Kibiri, Nandi North, and Nandi South forest ecosystems for medicine. CVM surveys were conducted according to guidelines suggested by Whittington (2002), Hanley *et al.* (2007), Ojeda *et al.* (2007) and Riera and Signorello (2013). In personal interviews, a hypothetical conservation scenario was described and respondents were asked to state their maximum contribution to a local fund to ensure the continued provision of services or the existence of the forest. The payment vehicle was an annual contribution to a community development fund. This payment vehicle was adopted because the local people in Kakamega, Nandi North, and Nandi South forest ecosystems often contribute to local community infrastructure projects; for example, school classrooms are funded through the "pool together" approach popularly known as Harambee. An open-ended value elicitation technique was adopted with a checklist of the amount on the questionnaire, and the respondent was asked to state the maximum amount he or she would be willing to pay for each of the services. To minimize the problem of free riding, the respondents were provided with a range of monetary values from KES 100 to KES 15,000. These values were derived

from Focus Group Discussions on the minimum and maximum amounts local people could pay for voluntary contributions in local fund raising (Harambees). Frequency distributions for the maximum WTP for each service were determined. The mean and the median of the sample were computed using the descriptive functions in SPSS (IBM version 20). To obtain the aggregate population WTP, the sample mean was multiplied by the population size (Hanley *et al.*, 2007; Riera & Signorello, 2013). This is equivalent to the horizontal summation of individual willingness to pay across individuals who constitute the total population adjacent to the Kakamega, Nandi North, and Nandi South forest ecosystems.

The Bequest valuation equation:

$$V_b = \sum_{i}^{n} (W_b * N_b)$$

V_b- is the value of medicinal use; W_b- WTP, N_b- number of households in landscape (Ezebilo & Mattsson, 2010; Langat *et al.*, 2019).

Data Collection and Analysis

Primary data collected included the 1) local name of plant; 2) disease and condition treated by plant; 3) plant part (s) used for the treatment; 4) preparation method; 5) the indigenous, common and scientific name of the plants and their willingness to pay to conserve medicinal plants. The results were summarized in unidimensional tables to identify the medicinal plants that are most used by the respondents. The collected ethnomedicinal data were analyzed using different quantitative analyses, including relative frequency citation (F), Species prevalence (SP) use value (UV) of medicinal plants among communities living around the Kakamega ecosystem (Tardío & Pardo, 2008).

RESULTS AND DISCUSSIONS

Socio-economic Characteristics of Respondents

Among the 464 respondents interviewed in this study (Table 1), 57.8% (n=268) had primary education, secondary 28.4%, (n=132), college 6.0%, (n=28), university education 3.2% (n=15) and postgraduate education (0.4%, n=2) while those who had no education were 4.1% (n=19) of the total. Those who use medicinal plants were 96% (n=18) among those without education, primary 93% (n=248), Secondary 90% (n=119), tertiary level 89% (n=25), university degree 80% (n=12) and postgraduate 50% (n=1). The results ($\chi 2=20.2$, $p=0.45$) indicates that education level was not statistically significantly associated to the usage of medicinal plants. The majority of females use medicinal plants (97%) compared to their male (89%).

Plant Parts used, Mode of Preparation, Dosage and Administration of Remedies

Leaves of the medicinal plants were the most commonly used plant part constituting 31 % (n=26) of the preparations, followed by roots with 20% (n=17), bark with 14% (n=14), fruits with 11 % (n=9), seeds having 11% (n=9), flowers 2% (n=2) and sap 2 % (n=3) (Figure 2).

Complete information about each plant species includes botanical name, family, common name, part used, either utilized to treat human or animal diseases or both, and their recipes are listed in Tables 2 and 3.

Taxonomic Diversity, Life Forms and Plant Medicinal Applications

Thirty-two key species of medicinal plants were identified and used by local people around the Kakamega forest ecosystem. The thirty-two plant species with medicinal values were found to be distributed within 24 plant families (Figure 3).

Table 1: Socio-demographic characteristics of respondents that used medicinal plants for the treatment or prevention of various diseases/ailments within Kakamega Forest Ecosystems

Variable	Categories	Use Medicinal plants (%, n)		Chi-square (χ^2) (p-value)
		Yes	No	
Level of education (%)	Basic primary	92.5 (248)	7.5 (20)	20.2 (0.45)
	Secondary	90.1 (119)	9.9 (13)	
	College	89.3 (25)	10.7 (3)	
	University undergraduate	80 (12)	20 (3)	
	Post graduate	50 (1)	50 (1)	
	None	96 (18)	4 (1)	
Gender (%)	Male	88.8 (301)	11.2 (38)	7.4 (0.11)
	Female	96.9 (121)	3.1 (4)	
Age (Mean Year)	18-35	34 (24)	66 (46)	72.1 (0.17)
	36-60	54 (134)	46 (114)	
	60+	70 (102)	30 (44)	
Occupation (%)	Farming	91.1 (296)	8.9 (29)	20.2 (0.45)
	Livestock rearing	96.7 (269)	3.3 (9)	
	Formal employment	75 (42)	25 (14)	
	Business	90.6 (210)	9.4 (22)	
	Juakali	90.6 (42)	9.4 (4)	
	Forest products	89.0 (186)	11.0 (23)	

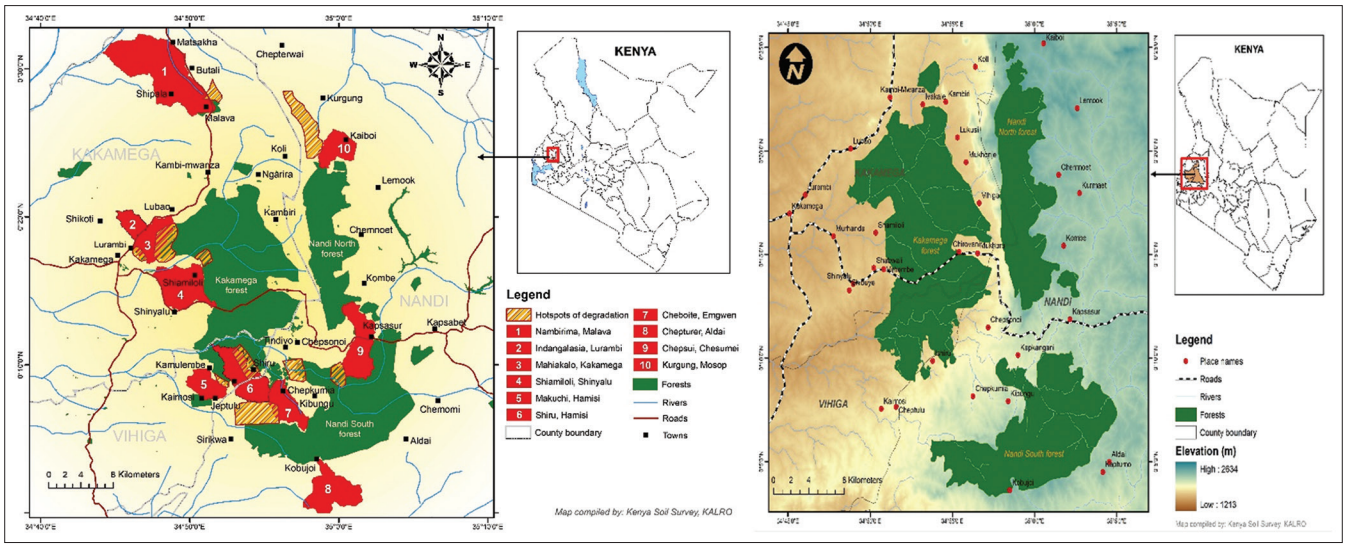

Figure 1: Study is Map of the Kakamega Forest Ecosystem

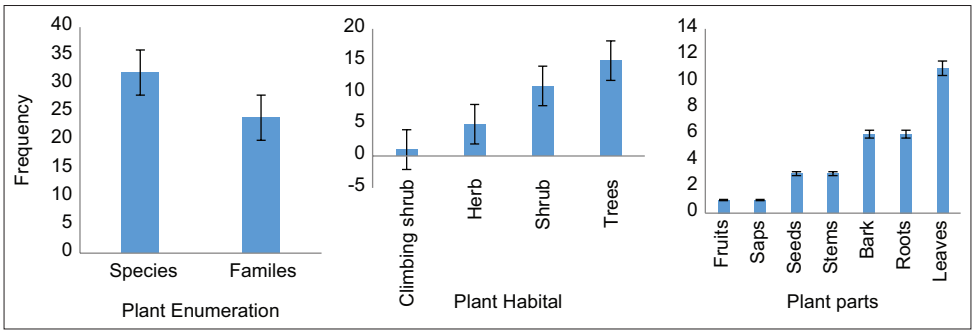

Figure 2: Plant numeration, habitat and parts used by the Communities around Kakamega Forest Ecosystem

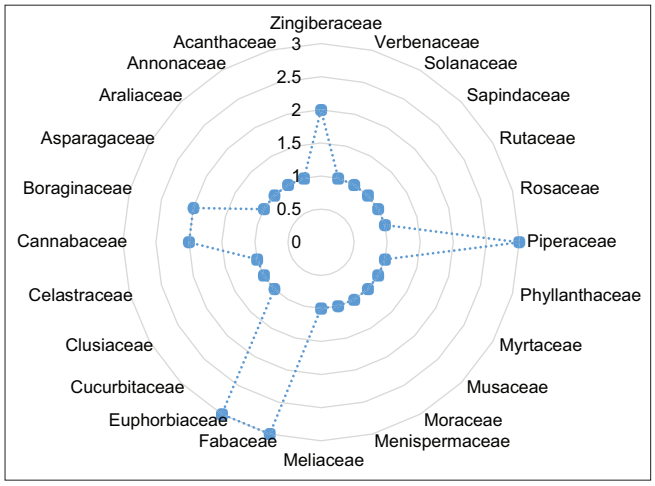

Figure 3: Distribution of medicinal plant species according to their numbers per family in the study area

Forty-seven percent (47%) of these were trees, thirty-four percent (34%) were shrubs, sixteen percent (16%) were herbs and climbers three percent (3%) (Figure 2). Seventy percent (70%) of the medicinal plants were within the forest and thirty percent (30%) were outside the forest.

Total Annual Economic Value of Medicinal Plants Extracted by Households

The annual economic values were based on the willingness to pay methods which provide strict measures of economic values, which are based on peoples' willingness to pay for a product or service. This is equivalent to the horizontal summation of individual willingness to pay across all who constitute the total population adjacent to Kakamega, Nandi North, and Nandi South forest ecosystems. The monetary value for the local community on medicinal plants in terms of direct-use value for communities in Kakamega, North Nandi, and South Nandi was aggregated to the value of ≈ KES 0.6 billion and the indirect use value as ≈ KES 0.3 billion (Table 4).

CONCLUSIONS

In conclusion, there it is evidenced from the study that there is sufficient indigenous knowledge among the community around the Kakamega forest about medicinal plant species. These medicinal plant species contribute not only to the sustainable provision of community health care but also have a high potential for economic well-being at the household level if conserved. Further its shows that much of this knowledge is still held mainly by a few elderly people and with the growing

Table 2: Common medicinal plants consumed by communities around Kakamega forest Ecosystems

Botanical name	Family	Common Name	Part (s) used	Medicinal therapeutic uses	Diseases/conditions Targeted
Piper umbellatum	Piperaceae	Cordoncillo	Leaves, roots and stems	Leaves	Ear problem, boils and burns.
				Root decoction	Jaundice, Malaria, Urinary and kidney problems, syphilis and gonorrhea.
				Stem	Expel tapeworms
Dracaena fragrans	Asparagaceae	Corn Palm	Leaves and roots.	Leaves	Used as blood purifier, stomachache and dysentery.
				Roots	A decoction of roots to treat gonorrhea.
Piper capense	Piperaceae	Wild pepper	Leaves	Aerial parts are used to treat epileptic attacks	throat, fever, stomach-ache, epileptic
Desmodium repandum	Fabaceae	tick-trefoil	Roots	Plant is used in combination with other diuretic substances	Stomach problem
Trichilia emetica	Meliaceae	Banket mahogany	Leaves, barks, seeds, fruits, bark	Oil extracted from the seeds and is used to moisturize the skin	Treating skin diseases
				Bark soaked in water	Treating intestinal ailments
				Decoction of barks and roots	Remedy for colds and pneumonia
				Decoction of roots	Treatment of infertility
Annona senegalensis	Annonaceae	African custard-apple	Leaves, bark, fruits, Stem- and root-barks	Bark and roots mixed with water	Vomiting, dysentery, respiratory
				Leaves	Treatment of pneumonia
				Bark	Treatment of warms, diarrhea, toothaches, healing of wounds
				Roots	Treatment of dizziness, indigestion and chest colds
Antiaris toxicaria	Moraceae	Sacking tree	Seeds, fruits, leaves and bark	The bark yields a latex applied to cuts, wounds and skin complains.	festering wounds and snakebites, antidysenteric
				Bark as an anodyne	Treatment of hepatitis
				Fruits	Are rich in vitamins
Acanthus eminens	Acanthaceae	Bear's breeches	Leaves, roots and other *parts*	Infusion of Acanthus leaves	Used for backache, skin diseases, coughs, eye infections, wounds and diarrhea.
				Leave paste	Snake bites
Ensete ventricosum	Musaceae	wild banana	corm, seed, and stem	Decoction of pounded leaves taken to stimulate labor.	Treat liver and miscarriage problems.
Aframomum melegueta	Zingiberaceae	Pepper Coast	Fruit, roots and seeds	Root is a pungent, seeds help to reduce and relief from nausea	Deworming. stomach ache and diarrhea
				Seeds	Cardiovascular disease, diabetes and inflammations.
Prunus africana	Rosaceae	African cherry	Bark and leaves	Bark for treatment and leaves are used as an inhalant for fever	Allergy and prostate cancer
				Bark extracts	Chest infections and diarrhea
Albizia gummifera	Fabaceae	Peacock flower	roots, bark, leaves and pods	Bark infusion	Treatment of malaria, treatment of headache, treatment of scabies, bark maceration body wash, and drink to treat Psoriasis
				Roots and leaves are purgative	Used to treat diarrhea and eye troubles.
Clausena anisata	Rutaceae	Perdepis	leaves or roots	Leaves and roots are taken for colds, rheumatism and arthritis	Influenza and headache
Maytenus heterophylla	Celastraceae	Common spike-thorn	roots, barks and leaves	Eaten as a vegetable	Snake bite, respiratory diseases. Inflammation, microbial affections and topical application for healing wounds.

(*Contd...*)

Table 2: (*Continued*)

Botanical name	Family	Common Name	Part (s) used	Medicinal therapeutic uses	Diseases/conditions Targeted
Cassia didymobotrya	Fabaceae	Candelabra Tree	leaves and young stems	Fresh leaves boiled in water for 30 minutes and taken	Cattle skin disease
				Decoction/infusion from the leaves, stems and roots	Are drunk as a laxative and purgative for the treatment of abdominal pain, ringworms and malaria
Croton megalocarpus	Euphorbiaceae	croton tree	bark, seeds, roots and leaves	bark is taken as a vermifuge, Sap from leaves and young twigs applied to wounds	Tuberculosis, whooping cough, pneumonia, wound clotting
Peponium vogelii	Cucurbitaceae	Peponium	fruits, stem, root, seed and flowers	The dried, powdered leaves are rubbed into scarifications when treating leprosy	Syphilis
Croton macrostachyus	Euphorbiaceae	Croton	leaves, bark, seeds, roots	boiled leaf decoction is drunk	Mumps
Stephania abyssinica	Menispermaceae	Stephania	roots, leaves	sap is taken with milk as an emetic to relieve	Aphrodisiac, chest pain and heart complaints
Allophylus abyssinicus	Sapindaceae	Forest velvet false-currant	Roots, leaves , Fruits	Roots are grated and eaten in small quantity	Coughs and rheumatism
Piper guineense	Piperaceae	Ashanti pepper	Fruits, leaves	The roots are chewed and the juice swallowed as aphrodisiac	Used as aphrodisiac
Trema orientalis	Cannabaceae	Charcoal Tree	Bark and leaves	Both bark and leaf decoctions are used as a gargle, inhalation, drink, lotion, bath or vapour bath	Coughs, sore throat, asthma, bronchitis, gonorrhea, yellow fever, toothache
Harungana madagascariensis	Clusiaceae	Haronga	Bark, sap and gum	Sap expressed from the inner bark is taken slightly warmed as a purgative	Skin complaints and conditions where blood is manifest.
Bridelia micrantha	Phyllanthaceae	Coast Goldleaf	Roots, Back Leaves and sap	The bark, roots are boiled to make a soup for treating diarrhea	Treat burns, wounds, venereal diseases, tapeworm, diarrhea and toothache.
Celtis gomphophylla	Cannabaceae	Gommopyhlla	Roots and leaves	Root is decoction to treat fever and menstrual pains	Cardiovascular disorders
Cordia africana	Boraginaceae	Cordia	Leaves, root and bark	wood-ash, mixed with butter, is applied to certain skin-troubles	headache, nose bleeding, dizziness and vomiting during pregnancy, and worms, gonorrhea and skin rushes
Lantana camara	Verbenaceae	Lantana	Leaves, root, flowers	A decoction of the dried flowers, roots, roots	skin itches, as an antiseptic for wounds, leprosy and scabies
Eucalyptus saligna	Myrtaceae	Sydney Blue Gum	Trunk, leaves	Kino resin can be Diluted taken internally as an effective treatment for dysentery,	Dysentery, gargle and mouthwash to treat relaxed throat, loose teeth
Markhamia lutea	Bignoniaceae	Siala	Leaves, bark, roots	leaves and bark are pounded up with citron juice to a paste, and the liquid is expressed for use as a lotion	Skin-affections, sores and itch, eye problem, throat problem
Neoboutonia macrocalyx	Euphorbiaceae	Neoboutonia	Stem and bark	Bark is used to treat headache and fever	Malaria, liver problems, fever
Polyscias fulva	Araliaceae	Polyscius	Bark, leaves	bark is taken for the treatment of fever and malaria,	Malaria, fever and mental illness
Solanum incanum	Solanaceae	Bitter Apple	leaves, roots or fruits	leaves, roots or fruits are used in decoction, or the roots are chewed or the sap swallowed	sore throat, angina, stomach-ache, colic, headache, painful menstruation, liver pain and pneumonia and rheumatism

Table 3: Ethnomedicinal plants species, families, ecological status, and other indices

Botanical name	Family	Common Name	Life forms	(F)	SP	UV
Croton megalocarpus	Euphorbiaceae	croton tree	Tree	26	13.0	0.52
Piper guineense	Piperaceae	Ashanti pepper	Climber	25	12.5	0.50
Antiaris toxicaria	Moraceae	Sacking tree	Tree	17	8.5	0.34
Polyscias fulva	Araliaceae	Polyscius	Tree	14	7.0	0.28
Piper umbellatum	Piperaceae	Cordoncillo	Shrub	13	6.5	0.26
Prunus africana	Rosaceae	African cherry	Tree	13	6.5	0.26
Solanum incanum	Solanaceae	Bitter Apple	Herb	10	5.0	0.20
Piper capense	Piperaceae	Wild pepper	Shrub	9	4.5	0.18
Trema orientalis	Cannabaceae	Charcoal Tree	Tree	9	4.5	0.18
Aframomum melegueta	Zingiberaceae	Pepper Coast	Herbs	7	3.5	0.14
Cordia africana	Boraginaceae	Cordia	Tree	6	3.0	0.12
Dracaena fragrans	Asparagaceae	Corn Palm	Shrub	5	2.5	0.10
Neoboutonia macrocalyx	Euphorbiaceae	Neoboutonia	Tree	5	2.5	0.10
Albizia gummifera	Fabaceae	Peacock flower	Tree	4	2.0	0.08
Harungana madagascariensis	Clusiaceae	Haronga	Shrub	4	2.0	0.08
Eucalyptus saligna	Myrtaceae	Sydney Blue Gum	Tree	4	2.0	0.08
Desmodium repandum	Fabaceae	tick-trefoil	Herbs	3	1.5	0.06
Trichilia emetica	Meliaceae	Banket mahogany	Tree	3	1.5	0.06
Acanthus eminens	Acanthaceae	Bear's breeches	Shrub	3	1.5	0.06
Celtis gomphophylla	Cannabaceae	Gommopyhlla	Tree	3	1.5	0.06
Markhamia lutea	Bignoniaceae	Siala	Tree	3	1.5	0.06
Peponium vogelii	Cucurbitaceae	Peponium	Herbs	2	1.0	0.04
Maytenus heterophylla	Celastraceae	Common spike-thorn	Shrub	2	1.0	0.04
Lantana camara	Verbenaceae	Lantana	Shrub	2	1.0	0.04
Annona senegalensis	Annonaceae	African custard-apple	Shrub	1	0.5	0.02
Ensete ventricosum	Musaceae	wild banana	Herbs	1	0.5	0.02
Clausena anisata	Rutaceae	Perdepis	Shrub	1	0.5	0.02
Cassia didymobotrya	Fabaceae	Candelabra Tree	Shrub	1	0.5	0.02
Croton macrostachyus	Euphorbiaceae	Croton	Tree	1	0.5	0.02
Stephania abyssinica	Menispermaceae	Stephania	Shrub	1	0.5	0.02
Allophylus abyssinicus	Sapindaceae	Forest velvet false-currant	Tree	1	0.5	0.02
Bridelia micrantha	Phyllanthaceae	Coast Goldleaf	Tree	1	0.5	0.02

F = Frequency, SP = Species Prevalence and UV = Use Value

Table 4: Total annual economic value of forest products by households per year

Use Values	Kakamega	Nandi North	Nandi South	Kibiri	Total
Monetary value of local communities' consumptive use	309,386,463	158,740,728	3,898,934	129,892,131	601,918,256
Indirect use values	65,877,550	67,065,170	115,777,695	68,567,631	317,288,046
Total Value	**375,264,013**	**225,805,898**	**119,676,629**	**198,459,762**	**919,206,302**

interest; unlocking such knowledge from the control of a few to the wider population through an "accelerated" social construction process such as through sustained public awareness campaigns, should be encouraged. The indigenous knowledge of medicinal plants has a very high potential for boosting economic empowerment of the counties and local community surrounding the forest ecosystems hence the need to the conservation of medicinal plants from exhaustive utilization in-situ and ex-situ.

AUTHOR CONTRIBUTIONS

All authors conceived and designed the field study protocols; S. O. Ojunga, K. Owange, K. C. Muskiton, M. Wanyiri & M. Isack collected field data; while D. K. Langat, S. Ojunga and J. Otuoma analyzed the data; all the authors contributed to the write-up.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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