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Research Article

Unsustainable Harvesting Practices and Vulnerability of Medicinal Plants in Nasarawa-Eggon Local Government Area, Nasarawa State, Nigeria

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ABSTRACT
Humans have impacted their environment through complex interactions that have shaped their lives and the resources around them. Some of these interactions have resulted in unsustainable practices with serious consequences for both humans and the environment. One such unsustainable practice is the increasing pressure of overreliance on medicinal plant resources driven by cultural beliefs and socio-economic realities. This study evaluated the impacts of conventional methods of harvesting medicinal plants on conservation. A semi-structured questionnaire was used to interview 178 participants. Data were also collected through focused group discussions and transect plots. Five sampled plots of 20m × 20m (400 m^2) for trees and shrubs and 1m × 1m for herbs. The study documented 54 medicinal plants. Results showed 26.04% of roots and whole plants were removed, with 56.25% of assessed species exhibiting moderate-to-high vulnerability. Spearman's correlation analysis between harvesting risks and relative abundance of medicinal plants showed a negative correlation, although not statistically significant ($r = -0.398$, $p = 0.127$). Multiple regression analysis showed a positive relationship for medicinal plants used ($R = 0.542$). The study revealed unsustainable harvesting practices and recommends prevention of possible local extinction through urgent government intervention. Government agencies and traditional medicine practitioners (TMPs) should be encouraged through policy formulation to integrate vulnerable species in their farms and gardens. Government should also promote participatory conservation through local community conservation management.

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1 Introduction

The complex relationship between man and the natural environment has led to significant modifications of the environment with devastating consequences. Although climate change is a critical factor, deforestation as a result of human and agricultural expansion is causing serious ecological disruption, decline in biodiversity, and loss of livelihood. The environmental components that suffer the most negative impact of man interaction with the environment are vegetation and plant resources (Prasad, 2023). Plant resources provide the basis for not only climate modification, food and medicine but also for livelihood (Khakurel et al., 2024). For many years, medicinal plants were the core of the traditional healthcare system globally. Over 80 percent of people in the developing world depend on medicinal plants for their healthcare needs (Latif & Nawaz, 2025).

Global population growth, particularly in the developing world, has amplified the pressure on commonly used medicinal plant resources through uncontrolled wild harvest with attendant decline in resource availability. The growing interest in forest resources impacts plant species density and diversity and the population of wildlife, leading to degradation of the ecological system (Abubakar & Zankan 2025). Reliance on medicinal plant resources results from generations of indigenous knowledge and beliefs driven by culture and heritage. Increasing use of medicinal plants has intensified pressure and threats on the resources because these plants are gradually becoming scarce and rare. High demand has led to unsustainable harvesting practices, which limit the regeneration potential of medicinal plants and facilitate death or extinction. It has become crucial to sustainably manage medicinal plants as global interest increases the pressure and threatens their sustainability (Jin & Huang 2024).

The surge in interest in herbal medicine and plant-based products is driven by the increasing awareness that plant-based therapies are natural, accessible, and affordable (Chen et al., 2016; Astutik et al., 2019; Wani et al., 2021). Rahman et al. (2011) reported a preference for herbal medicine for the treatment of illnesses. Many different animals' diseases (Livestock and Poultry) are also reported to be treated with medicinal plants (Laudato & Capasso, 2013). The growing interest in medicinal plants and herbal remedies is also driven by the desire for natural alternatives to conventional medicine, increasing awareness of the potential benefits of medicinal plants, as well as increasing incidences of chronic diseases and illnesses that prove resistant to conventional drugs (Amer & Mohammad, 2022; Nenungwi et al., 2025). Also, a study on the "Conservation and Sustainable Use of Traditional Medicinal Plants in Zimbabwe" has shown

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that economic crisis has made allopathic medicine unaffordable for the majority of the population, with individuals who once did not use traditional medicine now turning to it as an alternative form of treatment (Chapeyama, 2009).

To meet the healthcare needs of the growing population and the increasing regional and global healthcare market, medicinal plant resources are being exploited in large quantities from the wild (Meena et al., 2024; Brinckmann et al., 2018). Most damage to medicinal plants harvested in the wild is done by people who are involved in wild gathering for commercial purposes (Astutik et al., 2019; Corlett, 2016; Rahman et al., 2011). Some studies have shown financial benefits from medicinal plants, with increased trade in some endangered species observed in India and Vietnam Astutik et al., 2019). Pei et al. (2020) reported commercialization of some medicinal plants, of which about 26 were designated as endangered species. Bareetseng (2022) projected an increase in the global herbal market to the tune of USD 104.78 billion by 2026 at a Compound Annual Growth Rate of 6.5%, while the WHO estimates that the trade will increase to about US$ 5 trillion by 2050 (Asigbaase et al., 2023).

Increased global demand for medicinal plant resources and climate change have placed about 15,000 medicinal plant species at risk of extinction worldwide, with 20% of species in the wild reported to be almost depleted due to growing population and increased usage (Ssenku et al., 2022). Trends have also shown that demand for herbal drugs will continue to grow with attendant pressure on available medicinal plants, as reported by Meena et al. (2024). Many plant species are harvested faster than they can replenish as demand grows. Overexploitation and depletion of slow-growing, delicate species could lead to extinction (Astutik et al., 2019; Chen et al., 2016). Medicinal plants provide both healthcare benefits and economic opportunities, as well as support for ecological function and healthy ecosystems; a vital role in sustainable development (Theodoridis et al., 2023).

However, indiscriminate exploitation and destructive harvest have led to limited availability of some valuable species and pose a risk to human health and endanger the survival of these plants in the wild. In Nigeria, previous ethnobotanical studies have shown limited focus on the ecological impact of medicinal plant harvest. Whereas some studies focused on broad deforestation (Abubakar & Zankan, 2025), others investigate the factors responsible for the use of medicinal plants (Sambe et al., 2022), while some mostly centred on medicinal plants identification, local abundance and bioactivity (Ibrahim et al., 2016), leaving a knowledge gap between harvesting practices and vulnerability of medicinal plants. This knowledge gap creates uncertainty about the ecological impact of harvest on the plant resources (McGeoch et al., 2008; Verpoorte, 2024), which this study aims to address. As traditional medicine gains global significance, it is crucial to integrate medicinal plants conservation into planning processes. This will enhance future supply of resources and material needs.

2 Materials and Methods

2.1 Study Area

The study was carried out in three communities (Wakama, Alushi-Ginda communities in Akun development area and Nasarawa-Eggon metropolis) located in Nasarawa-Eggon Local Government Area in Nasarawa State, North-central Nigeria. The study area lies between latitudes 8°33" and 8°52" North and between longitudes 8°14" and 8°39" East. The town is 163.2km from Abuja, the nation's Federal Capital Territory, and 29.2 km from Lafia, the Nasarawa State Capital. The study area covers a landmass of about 1,208 square kilometres with an estimated population of 229,100 (115,008 Males and 114, 092 Females) at the National Population Commission (NPC, 2022) projection. The LGA hosts a number of hills and elevations, such as the popular Eggon Hills, which is a major tourist attraction in the area. It has a mean temperature of 15.6 °C and 26.7 °C, with annual rainfall between 1317 mm and 1450 mm of rainfall per annum. The climate of Nasarawa Eggon falls within the tropical savannah climate with two clearly marked seasons (wet and dry). Rainfall begins from April to October, and the months from December to February experience the north-east trade winds, and thus the dry Harmattan winds (Ezekiel & Dominic, 2014; Yahaya et al., 2024). The area has a maximum and minimum temperature of 81.7° F and 16.7° F respectively. The area is underlain by granite, rhyolites, basalt/dolerites, and gneisses, which are Precambrian in age. The soil is acidic with moderate heavy metal contamination. The acidic nature of the soil potentially limits crop yield. Farmers in the Nasarawa-Eggon area improve the soil for optimum crop yield by using organic manure application and conservation tillage to manage soil fertility (Onwuka et al., 2022). The vegetation is made up mainly of grasses and isolated trees. Trees of economic and medicinal value that could be found in the area are locust bean tree (*Parkia biglobosa*) and shea butter (*Vitellaria paradoxa*); others include oil palm tree, *Albizia lebeck, Prosopis africana, Khaya senegalensis*, among others (Kwon-Ndung et al., 2018). Agriculture serves as the primary economic activity and is vital for food security and employment in the region. Additionally, the LGA has potential for local trade and small-scale industries, contributing to economic growth.

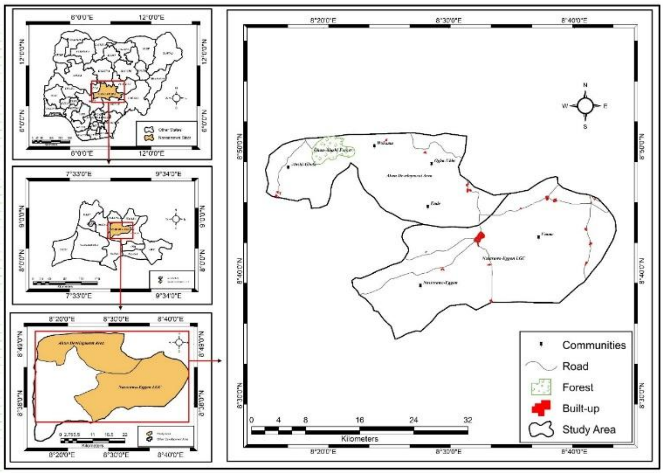

Figure 1: Map of Nasarawa State showing the study area

2.2 Sampling and Sample Size

The study was carried out between October 2025 and March 2026. Three communities were purposively selected for this study due to their heavy dependence on traditional medicine for the treatment and management of different ailments and diseases, as well as having a good number of practitioners. These communities are Wakama, Alushi-Ginda, and Nasarawa-Eggon communities. Participants in the study include Traditional Medicine Practitioners (TMPs) comprises of both genders. Others include herbal medicine users. Thirty-three practitioners participated in the study, with ten members of the National Association of Nigeria Traditional Medicine Practitioners (NAN TMPs) Akun chapter serving as key informants for interviews and the ranking of major threats to the ecological sustainability of medicinal plants in the study area. Residents who had resided in the communities for 10 years and were 20 years old or older were considered mature and knowledgeable about medicinal plants and were included in the study (Asigbaase et al., 2023; Jadid et al., 2020).

Participants were randomly selected, while the selection of key informants (traditional medicine practitioners TMPs and community elders) was based on a purposive and snowball sampling approach due to their ethnobotanical knowledge (Jadid et al., 2020). The sample size for the study was determined by using Yamane's formula (Yamane, 1967): n = N/(1 + N(e2), where n = sample size, N = number of households, and e = error margin. An error margin of 0.075, the midpoint between 0.05 and 0.1, which are the conventional error margins, was applied (Asigbaase et al., 2023). N was calculated by dividing the total population of the study area by the average number of persons per household (7) obtained from the National Population Commission (NPC, 2022). Two hundred and twenty-three respondents were sampled using pretested semi-structured questionnaires. Forty-five of the total number of questionnaires administered were incomplete, while one hundred and seventy-eight correctly completed questionnaires were used for the study.

2.3 Data Collection and Botanical Identification

Questionnaires, interviews, focused group discussions (FGD), and ecological survey plots were used. The questionnaire was randomly distributed among participants. The questionnaire was written in the English language and translated for respondents who could not read it in the local language (Asigbaase et al., 2023). Key informants identified medicinal plants commonly used in the study area by their local names (Eggon and Hausa). Information about the conservation status of plant species was obtained from the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2025). Population sampling of medicinal plants was conducted in the open forest (Ohon-Alushi) in the Alushi-Ginda community.

Data were collected from five sampled plots of 20m × 20m (400 m^2) for trees and shrubs and 1m × 1m for herbs. The plots were systematically selected. Data such as medicinal plant species, number of each species, and evidence of harvesting practices (cutting, uprooting, debarking) were documented. These data were then used to calculate the relative abundance of species and their correlation with the harvesting pressure index in order to assess local vulnerability and ecological sustainability. Plant specimens were identified and compared with already verified medicinal plants of Nigeria, North Central volume two, published by Nigeria Natural Medicine Development Agency (NNMDA), and were deposited at the medicinal plants herbarium of Nigeria (MPHN).

2.4 Data Analysis

Data obtained from questionnaire administration and survey plots were coded and analysed using Statistical Package for Social Science (IBM SPSS Statistics 27.0.1) in accordance with the specific objectives of the study.

2.4.1 Documentation of commonly used medicinal plant species and harvesting practices in the study area

Data from questionnaire administration and ethnobotanical survey were used. Medicinal plant species, plant parts harvested, and the types of harvesting practices reported by the respondents were documented. The medicinal plant specimens were identified and compared with already verified medicinal plants of Nigeria, North Central volume two, published by Nigeria Natural Medicine Development Agency (NNMDA), and were deposited at the medicinal plants herbarium of Nigeria (MPHN).

2.4.2 Assessment of local vulnerability index of commonly used medicinal plants in the study area

To assess the local vulnerability index of medicinal plant resources in the study area, four pressure parameters were used: harvesting pressure impact HPI), represented by (P_1), relative abundance (RA), represented by (P_2), relative frequency of citation (RFC), represented by (P_3), and harvesting risk (HR), represented by (P_4). This method was adopted from (Ngamsou et al., 2024; Tchapda et al., 2022).

Table 1: Parameters for calculating vulnerability index (VI)

Parameters	Low (scale = 1) VI < 2	Moderate (scale = 2) 2 ≤ VI < 2.5	High (scale = 3) VI ≥ 2.5
HPI (P1)	P1 < 3.60	3.60 ≤ P1 < 3.70	P1 ≥ 3.70
RA (P2)	P2 ≥ 39.50%	39.50% > P2 ≤ 39%	P2 < 39%
RCF (P3)	P3 < 3.50%	3.50% ≤ P3 <3.60%	P3 ≥ 3.60%
HR (P4)	Picking/Plucking	Debarking, Stripping, Cutting, Milking	Digging/Uprooting

Source: Adapted from Ngamsou et al. (2024) and Tchapda et al. (2022)

These pressure parameters were obtained from focus group discussions (FGD) and ecological data from the surveyed plots.

The harvesting pressure impacts (HPI) were calculated using the formula HPI = UV x HR (adopted from Meer et al., 2024). This equation links the usefulness of a medicinal plant (UV) and the associated ecological risk (HR). While the use value (UV) emphasises cultural demand due to the importance of the plant, the harvesting risk (HR) represents its ecological vulnerability due to the parts harvested or the method of harvesting. For instance, root harvesting poses a greater threat (higher risk score) to the plant than leaf or fruit harvesting (lower risk score). With the harvesting pressure index (HPI), highly pressured species (high UV and HR) and least pressured species (low UV and HR) can be identified for conservation priority. Others with high UV and low HR or low UV and high HR can also be assessed using the equation.

The species use value (UV) is calculated by considering each reported use of species (from key informants) and dividing it by the total number of participants. The species use value (UV) is the value of the species to the local communities with regard to medicinal use. It shows the medicinal importance of the species in the community. UV was estimated using the equation:

$$UV=\sum UR/N$$

Where: UV is the species use value, UR is the species use report from all respondents, and N is the total number of participants.

The study used a scale of 1 to 3 to represent levels of pressure on species. Low pressure is scored 1, a value of 2 represents moderate pressure, and a value of 3 represents high pressure (Table 1). The harvesting risk (HR) scores were assigned by considering the harvesting method of that species with the highest risk. This implies that if a medicinal plant is harvested using more than one method, the one with the highest risk score would be chosen. The risk scoring considers the potential severity of the harvesting parts and their ecological impact, which is consistent with ethnobotanical assessment and aligns with the precautionary principle. The highest risk method (root harvesting) was used because some plants are subjected to multiple harvesting methods. Root harvesting carries high risk (lethal extraction), and leaf picking carries low risk (renewability); this represents a fair estimate of vulnerability in the study area.

The moderate scale is the midpoint of the range; it is obtained by averaging the values of the range (the lowest and highest values of the range are added together, and then divided by 2). Vulnerability index (VI) is calculated using the formula:

$$VI = \sum \frac{P1 + P2 + P3 + P4}{N}$$

Where N is the total number of the pressure parameters considered.

RA was calculated by computing the density of each species (number of species per unit area) and then compared to the total density of all the species within the transect plots.

$$RA = \frac{\textit{Density of a species}}{\textbf{Total density of all species}} \times 100$$

The relative frequency of citation (RFC) captures the average number of participants who cited a medicinal plant for use (frequency of citation), against the total number of participants in the study, given by RFC = $\frac{FC}{N} \times 100$, where FC = frequency of citation and N = number of participants in the study.

2.4.3 Socio-economic factors influencing the use of medicinal plant resources in the study area

Multiple regression analysis was carried out using

Statistical Package for Social Science (SPSS) to assess the influence of selected socio-economic variables, including age, education level, location and occupation, on the usage of medicinal plant resources.

2.4.4 Ranking of major threats to the ecological sustainability of medicinal plant resources in the study area

Ten key informants were chosen in accordance with (Awoke et al., 2024) to rank ecological threats. Participants were asked to rank ecological threats to medicinal plant sustainability based on five scale (1 = least and 5 = highest). A ranking index was used to add up the scores; threats with higher scores based on the ranking were considered greater threats to medicinal plants in the study area, and the information was used to prioritise biodiversity conservation interventions.

2.4.5 Limitations

We wish to respectfully clarify that this study did not undergo formal IRB/ethical review; the study design relied on voluntary informed verbal consent from all participants before data collection. We also ensured strict adherence to the International Society of Ethnobiology code of ethics. Permission was also obtained from the traditional ruler of the communities before commencement of the study. Sensitive personal or private information was not collected, and data collected were anonymously analysed.

3 Results and Discussions

3.1 Documentation of Medicinal Plants and Harvesting Practices in the Study Area

The study documented 54 species of medicinal plant resources from 36 families for the treatment of various diseases in the study area. All the 54 medicinal plant species in the study area are used for the treatment of human diseases, while only 5 (9.259%) were identified for the treatment of both human and livestock diseases (Table 2). This is probably because of the occupation of the people in the study area. Being mostly subsistence farmers, the people keep only a few animals, unlike the herder communities. This finding is similar but recorded more medicinal plant species than studies reported in Tanzania and Ethiopia by (Mwingira et al., 2023; Kindie et al., 2022), respectively. Other studies by (Kindie et al., 2022; Ma et al., 2019) also reported 40 and 42 medicinal plants, respectively, which is less than the numbers recorded in this study. However, Awoke et al. (2024) recorded more numbers than this study. The number of medicinal plant resources in a study area may vary depending on the number of informants, the culture of the people, and the duration and time of the collection (Awoke et al., 2024). Figure 2 shows the families of medicinal plants in the study area, with Fabaceae being the most prevalent, with 9 species representing (16.667%). This was followed by Asteraceae with 4 species representing (7.407%). Families with 2 species each were seven, representing a total of (25.928%), and others with 1 species each were twenty-seven, representing a total of (50.004%).

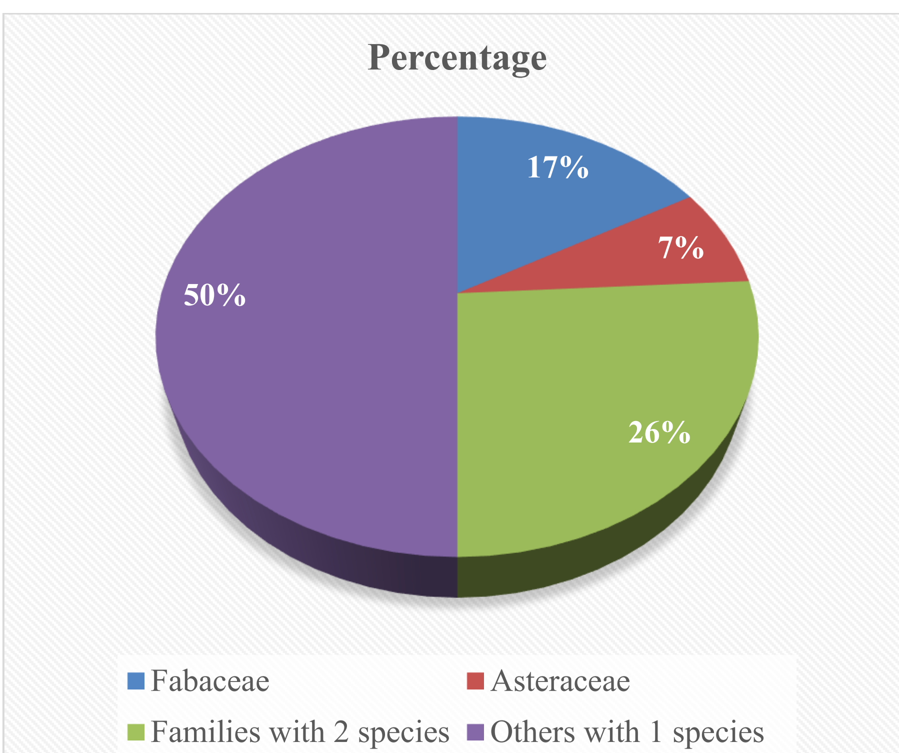

Figure 2: Families of medicinal plant resources in the study area

This finding varied with the observations reported by Awoke et al. (2024), where Solanaceae and Asteraceae were the dominant families. These observations could imply the possibility of shared bioactive compounds among medicinal plant species within the same taxonomic group. The dominance of Fabaceae in this study, however, could be a result of its ecological adaptability or biotic interactions in the study area. Another study by Ali et al. (2024) reported Amaranthaceae and Apocynaceae as more prevalent.

Table 2: Common medicinal plants and harvesting practices in the study area.

S/N	Species Names	Family Names	Local Names	Parts used	Harvesting Practices	FC	RFC	UV	UR
1	*Monechma ciliatum*	Acanthaceae	Ebor Awinshe	Whole plant	Cutting,	3	0.69	0.18	6
2	*Trianthema portulacatrum*	Aizoaceae	Inyi edu	Whole plant	Uprooting	4	0.92	0.24	8
3	*Amarantus spinosus*	Amaranthaceae	Kpangibi ezga	Whole plant	Uprooting	2	0.46	0.06	2
4	*Crinum glaucum*	Amaryllidaceae	Alibasa akla	Bulb	Digging, Uprooting	20	4.62	1.24	41
5	*Annona senegalensis*	Annonaceae	Ebor akla	Leaves, Stem, Bark	Cutting, Picking, Stripping/Debarking	18	4.16	1.88	62
6	Calotropis procera	Apocynaceae	Wargi abze	Leaves, Latex	Picking, Tapping	7	1.62	0.55	18
7	*Cussonia arborea*	Araliaceae	Angzo	Roots, Leaves, Bark	Digging, Picking, Debarking	6	1.39	0.70	23
8	*Borassus aethiopium*	Arecaceae	Akkah	Roots	Digging	3	0.69	0.09	3
9	*Sansevieria liberica*	Asparagaceae	Ambze	Leaves, Roots, Latex	Picking, Digging, Tapping/Milking	3	0.69	0.18	6
10	*Acanthospermum hispidum*	Asteraceae	Iyewu	Whole plant	Uprooting, Cutting	10	2.31	0.45	15
11	*Ageratum conyzoides*	Asteraceae	Engmo agba	Leaves, Bark	Picking, Debarking	8	1.85	0.36	12
12	*Tridax procubens*	Asteraceae	Eneyi	Whole plant	Uprooting, Cutting	12	2.77	0.36	12
13	*Vernonia perrottetii*	Asteraceae	Isi injumu	Leaves, Stem	Cutting, Uprooting	6	1.39	0.42	14
14	*Stereospermum kunthianum*	Bignoniaceae	Andzon eyi	Roots	Digging	8	1.85	0.64	21
15	*Kigelia africana*	Bignoniaceae	Abme	Bark, Fruit	Debarking, Picking	8	1.85	0.55	18
16	*Boswellia dalzielii*	Burseraceae	Afka ikpi	Bark, Leaves, Stem, Gum	Picking, Debarking, Milking, Cutting	4	0.92	0.45	15
17	*Lepidium sativum*	Brassicaceae	Ewhi/Ewi	Whole plant	Cutting	2	0.46	0.15	5
18	*Maytenus senegalensis*	Celastraceae	Ebgalushi	Bark, Roots	Digging, Debarking	5	1.15	0.58	19

19	*Parinari curatellifolia*	Chrysobalanaceae	Tangyu	Bark, Leaves, Fruits	Debarking, Picking	7	1.62	0.64	21
20	*Gueira senegalensis*	Combretaceae	Ispi	Roots, Leaves, Fruits	Digging, Picking	2	0.46	0.06	2
21	*Jatropha curcas*	Euphorbiacea	Kikida	Latex	Milking	20	4.62	1.67	55
22	*Alchornea cordifolia*	Euphorbiaceae	Ombye	Roots, Bark, Fruits	Debarking, Digging, Picking	4	0.92	0.24	8
23	*Erythrophleum suaveolens*	Fabaceae	Erhe	Bark, Roots	Digging, Debarking	9	2.08	0.61	20
24	*Piliostigma thonningii*	Fabaceae	Evomo	Leaves	Picking	9	2.08	0.82	27
25	*Parkia biglobosa*	Fabaceae	Enmo /Enno	Leaves	Cutting, Picking	11	2.54	0.33	11
26	*Abrus precatorius*	Fabaceae	Iyinbui	Leaves, Seeds	Cutting, Picking	6	1.39	0.24	8
27	*Isoberlinia tomentosa*	Fabaceae	Etakpa	Bark	Debarking	3	0.69	0.27	9
28	*Senna italica*	Fabaceae	Filasko	Leaves, Roots	Cutting, Digging	2	0.46	0.15	5
29	*Senna singueana*	Fabaceae	Rumfu	Leaves	Cutting	5	1.15	0.30	10
30	*Isoberlinia doka*	Fabaceae	Invikpa	Bark, Leaves	Debarking, Picking	5	1.15	0.48	16
31	*Detarium senegalense*	Fabaceae	Kplongbon	Roots, Bark, Fruits	Digging, Debarking, Picking	4	0.92	0.27	9
32	*Irvingia wombolu Vermoesen*	Irvingiaceae	Ogbono	Bark, Leaves	Debarking, Cutting	1	0.23	0.06	2
33	*Ocimum gratissimum*	Lamiaceae	Oyang	Leaves	Picking	5	1.15	0.33	11
34	*Vitex doniana*	Lamiaceae	Idzu/Izuh	Leaves, Bark	Debarking, Cutting	7	1.62	0.24	8
35	*Tapinanthus bangwensis*	Loranthaceae	Invigi	Leaves	Cutting	3	0.69	0.18	6
36	*Lawsonia inermis*	Lythraceae	Elelee	Roots, Leaves	Digging, Cutting	1	0.23	0.03	1
37	*Bombax buono pozense*	Malvaceae	Ikmuu akla	Bark, Leaves, Fruits, Seeds, Flowers	Debarking, Picking, Cutting	4	0.92	0.27	9
38	*Ceiba pentandra*	Malvaceae	Etendary	Bark	Debarking	4	0.92	0.12	4
39	*Khaya grandifoliola*	Meliaceae	Esso	Bark	Debarking	2	0.46	0.15	5

40	*Ficus sycomorus*	Moraceae	Anvah akyele	Bark	Debarking	12	2.77	0.52	17
41	*Moringa oleifera*	Moringaceae	Ikmu ango	Bark, Leaves	Debarking, Cutting	25	5.77	2.12	70
42	*Musa paradisiaca*	Musaceae	Agbor	Roots	Digging	7	1.62	0.21	7
43	*Eucalyptus globulus*	Myrtaceae	Eki waya	Leaves	Cutting, Picking	3	0.69	0.09	3
44	*Psidium gwajava*	Myrtaceae	Egweva	Leaves	Cutting, Picking	12	2.77	0.52	17
45	*Lophira lanceolata*	Ochnaceae	Envoh	Bark, Leaves	Debarking, Cutting	21	4.85	1.91	63
46	*Bridelia ferruginea*	Phyllanthacea	Ejebah	Bark, Roots, Fruits	Debarking, Digging, Picking	6	1.39	0.55	18
47	*Cymbopogon citratus*	Poaceae	Asso efpi	Leaves	Picking	25	5.77	1.52	50
48	*Securidaca longepedunculata*	Polygalaceae	Oshmoga	Leaves, Stem	Picking, Cutting	8	1.85	0.97	32
49	*Gardenia erubescens*	Rubiaceae	Engbreya	Roots, Leaves	Digging, Cutting	8	1.85	0.79	26
50	*Nauclea latifolia,*	Rubiaceae	Emre	Roots	Digging	25	5.77	2.27	75
51	*Vitellaria paradoxa*	Sapotaceae	Ezhba eggon	Bark, Seeds	Debarking, Picking	18	4.16	1.18	39
52	Simarouba amara	Simaroubaceae	Angbaki	Roots, Leaves, Fruits	Digging, Cutting, Picking	11	2.54	1.00	33
53	*Zingiber officinale*	Zingiberaceae	Shikita	Rhizome	Uprooting	5	1.15	0.30	10
54	*Aframomum angustifolium*	Zingiberaceae	Kpakpan ubmii	Rhizome	Uprooting	4	0.92	0.36	12

3.1.1 Medicinal plant parts used and harvesting practices

This study identified six categories of medicinal plant parts being harvested and five harvesting practices in the study area, respectively (Figure 3a and b). Based on local harvesting practices and the analysis of the total citation frequency of informants, leaf and stem cutting is the most parts used, representing 48.958%, followed by bark stripping (21.875%). Others are root (16.667%) and whole plant (8.333%), with gum and latex being the least parts used as medicine (4.167%). This finding agrees with the report of Awoke et al. (2024) and Mwingira et al. (2023), who both found that more than half of the people harvest leaves for use. The reason for these observations could be that these plant parts are more readily available and accessible as compared to other plant parts (Appiah et al., 2019).

On the contrary, while Meer et al. (2024) and Ali et al. (2024) both found an increase in harvest of whole plants, Singh et al. (2014) identified intensive root harvesting using destructive harvesting practices in India. Although this study recorded higher leaf harvesting, the combined pressure of root harvesting, bark stripping, and whole plant harvesting (51%) is significantly high and can cause a negative cumulative impact on the plant species in the study area (Figure 3a).

Whole plant removal and intensive harvesting of roots of medicinal plant resources is an unsustainable harvesting practice with a high risk of death and possible extinction of these resources.

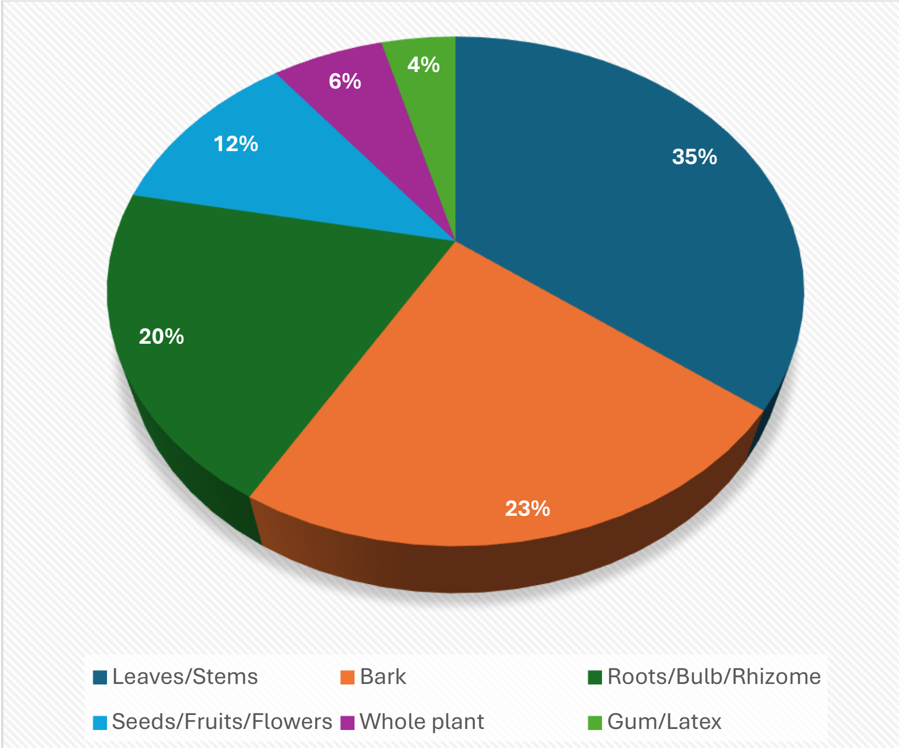

Figure 3a: Parts of medicinal plant resources harvested in the study area

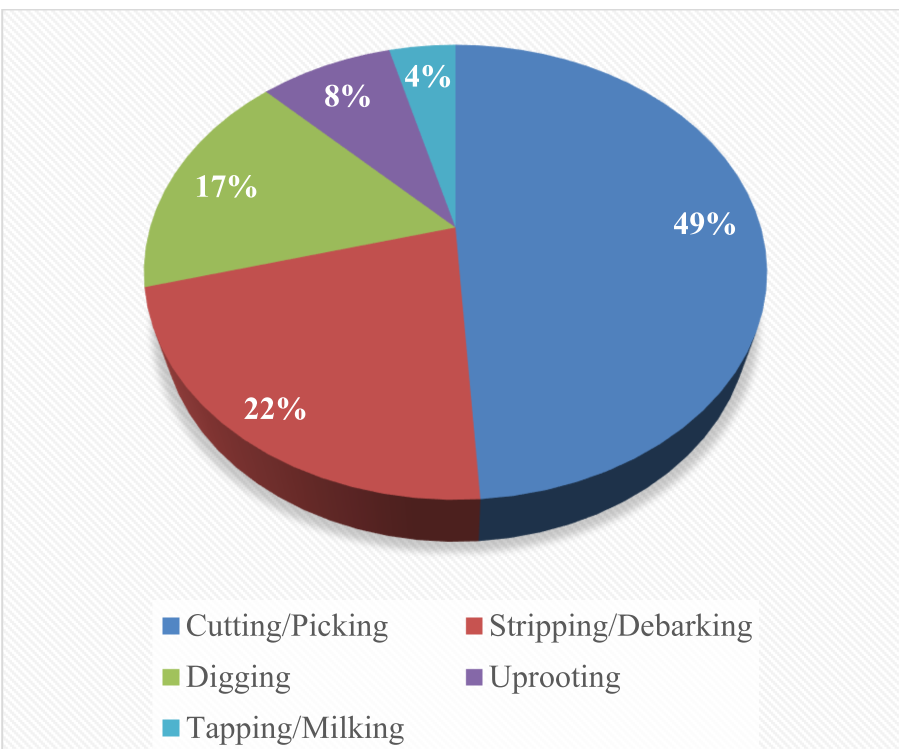

Figure 3b: Harvesting practices of medicinal plant resources in the study area

3.2 Assessment of vulnerability of commonly used medicinal plants in the study area

The vulnerability index (VI) was calculated using four pressure parameters: harvesting pressure impact (HPI), relative abundance (RA), relative frequency of citation (RFC), and harvesting risk (HR), adopted from Tchapda et al. (2022) and Christelle et al. (2020).

Table 3: Relative Abundance, Vulnerability Index and IUCN status of sixteen commonly used medicinal plants in the study area

S/N	Species Names	Parts used	Harvesting Practices	HR	HPI	RFC	RA/ha. (%)	VI	IUCN STATUS
1	*Crinum glaucum*	Bulb	Digging/Uprooting	3	3.72	4.62	13.50	3.00	NE
2	*Annona senegalensis*	Leaves, Stem, Bark	Cutting, Stripping/Debarking	2	3.76	4.16	72.05	2.25	LC
3	Calotropis procera	Leaves, Latex	Picking, Tapping	2	1.10	1.62	40.55	1.20	LC
4	*Cussonia arborea*	Roots, Leaves, Bark	Digging, Picking, Debarking	3	2.10	1.39	31.50	2.00	NE
5	*Kigelia africana*	Bark, Fruit	Debarking, Plucking	2	1.10	1.85	13.50	1.75	LC
6	*Maytenus senegalensis*	Bark, Roots	Digging, Debarking	3	1.74	1.15	31.50	2.00	NE
7	*Parinari curatellifolia*	Bark, Leaves, Fruits	Debarking, Cutting	2	1.28	1.62	13.50	1.75	LC
8	*Piliostigma thonningii*	Leaves	Picking	1	0.82	2.08	63.05	1.00	NE
9	*Parkia biglobosa*	Leaves	Cutting	1	0.33	2.54	45.00	1.00	LC
10	*Ficus sycomorus*	Bark	Debarking	2	1.04	2.77	18.00	1.75	LC
11	*Lophira lanceolata*	Bark, Leaves	Debarking, Cutting	2	3.82	4.85	31.55	2.75	NE
12	*Bridelia ferruginea*	Bark, Roots, Fruits	Debarking, Digging, Picking	3	1.65	1.39	9.00	2.00	LC
13	*Gardenia erubescens*	Roots, Leaves	Digging, Cutting	3	2.37	1.85	49.55	1.50	LC
14	*Nauclea latifolia*,	Roots	Digging	3	6.82	5.77	40.50	2.50	NE
15	*Vitellaria paradoxa*	Bark, Seeds	Debarking	2	2.36	4.16	22.50	2.25	VU
16	Simarouba amara	Roots, Leaves, Fruits	Digging, Cutting	3	3.00	2.54	4.50	2.00	LC

NE = Not evaluated, LC = Least concerned, VU = Vulnerable species

Table 3 shows the vulnerability of common medicinal plant resources used for treatment of diseases within the study area. Sixteen medicinal plant resources were evaluated for vulnerability based on the frequency of citation from key informants and the medicinal plants recorded from survey plots.

Out of the sixteen medicinal plants evaluated, three were highly vulnerable (VI≥2.5), representing 18.75%, six (37.50%) were discovered to be moderately vulnerable (2≤VI<2.5), while seven (43.75%) had a low vulnerability index (VI<2) (Table 3 and Figure 4). Sustained harvesting pressure on these species could be driving the medium-to-high vulnerability observed in 56.25% of the assessed plants in the study area. Other anthropogenic factors like climate change, agricultural expansion, and urbanisation could also be attributed to the vulnerability concern. This study aligns with the finding of Ngamsou et al. (2024), who reported high vulnerability of species of medicinal plants used for treatment against symptoms of COVID-19 in Cameroon.

One of the medicinal plants evaluated in this study, *Vitellaria paradoxa,* has been listed in the IUCN Red List of Threatened species (IUCN, 2025) as globally vulnerable, while six species, *Crinum glaucum, Cussonia arborea, Maytenus senegaleensis, Piliostigma thonnnengii, Lophira lanceolata and Nauclea latifolia* were listed as not evaluated, implying limited information about the global threat status (Table 3). This study, however, found five of these plants to be moderate-to-highly vulnerable in the study area, except for *Piliostigma thonnengii*. The absence of a global threat record or deficiency in conservation data of many medicinal plants in the study area present a serious concern and underscore the importance of this study, which provides these data at the local level of the study area. These observations were also reported by Asigbaase et al. (2023) while studying the conservation and economic benefits of medicinal plants in Ghana, where the researchers observed with concern the limited global conservation data for rare and vulnerable medicinal plant resources.

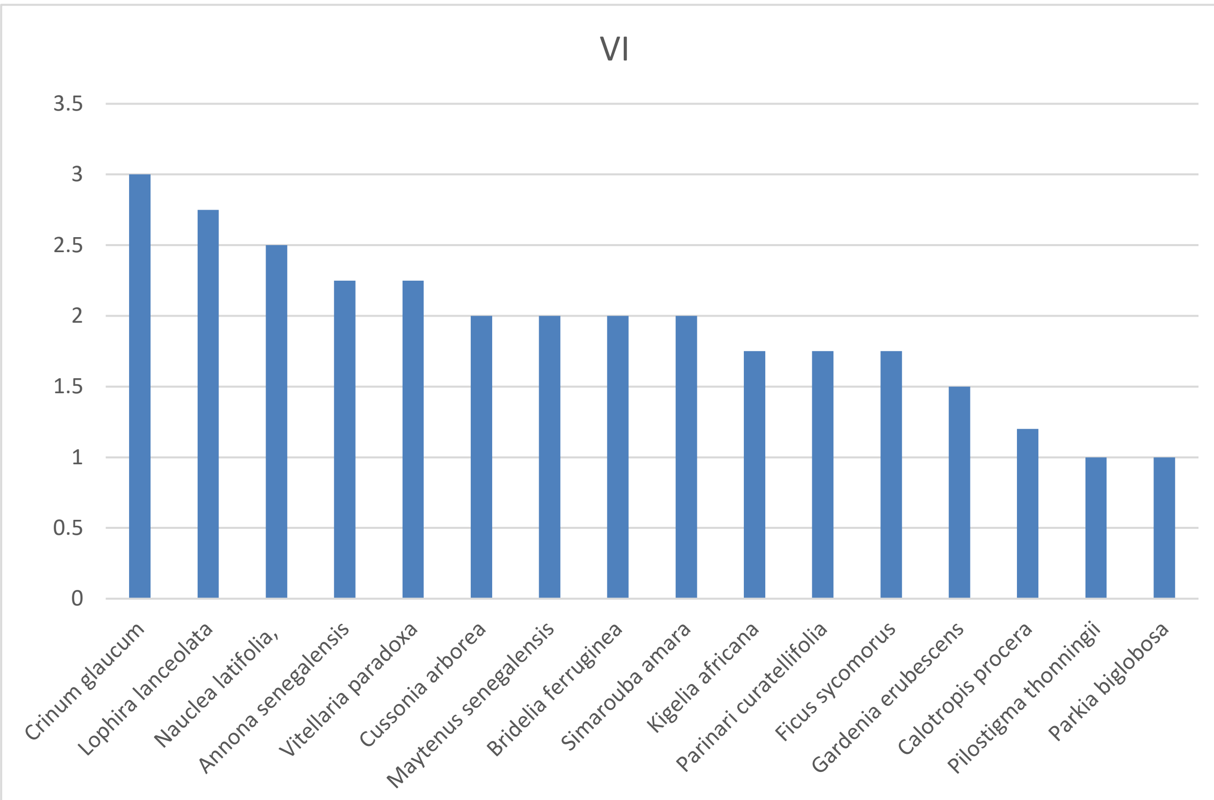

Figure 4: The vulnerability index of sixteen medicinal plants evaluated in the study area

Table 4 shows the demographic data of participants in the study. A total of 178 participants were involved in the study. The majority of the participants were male, accounting for 60.11% (n = 107), while the females made up 39.89% (n = 71). This implies that the harvesting of medicinal plants in the study area is dominated by males; a possible reason could be the position of males as heads of household who use medicinal plants as a measure to reduce the cost of living. The percentage of females who engaged in medicinal plants harvesting is also high (39.89%), implying that both men and women harvest medicinal plants in the study area. It shows community reliance on medicinal plant resources. This also explains why the vulnerability of the sixteen medicinal plants evaluated in the study area is high, with attendant low relative abundance. Root and bark harvesting practices were also observed in this study (Figure 2a). Excessive exploitation of these plant organs is highly detrimental to the survival of the plant and threatens ecological sustainability. Bukuluki et al. (2014) recorded similar observations in a study of harvesting practices and conservation implications in Uganda, where delicate plant organs were harvested.

The age range of the participants in the study started from 20 years and above. In the study, the largest proportion of participants were within the age group of 30–39, representing 32.58% (n = 58). This is followed by the age group of 40–49, which accounts for 26.41% (n = 47). The age group 20–29 covered 18.54% of participants (n = 33), participants within the age group 50–59 accounted for 11.80% (n = 21), and the least represented group is within the age group 60 and above, with 10.67% (n = 19). Table 4 shows that the most active age group (20– 49), represented by 77.53%, is actively involved in the harvesting of medicinal plants in the study area. The implication is that overreliance on these species, with the high percentage of unsustainable harvesting practices observed in this study (Figure 2), could have led to the high vulnerability and low relative abundance of species recorded in the study area. Oliveira et al. (2007) observed that harvesting frequency has a direct relationship with the availability of species; Bukuluki et al. (2014) also reported in a study that high demand and competition for wild medicinal plants resulted in unsustainable harvesting practices.

Unsustainable harvesting is a major concern facing medicinal plant resources, as these harvesting practices can lead to genetic erosion and decline of biodiversity.

Table 4: Socio-Demographic Characteristics of Respondents (N = 178)

Socio-Demographic Characteristics	Frequency	Percent (%)
Gender		
Male	107	60.11
Female	71	39.89
Total	**178**	**100**
Age		
20-29	33	18.54
30-39	58	32.58
40-49	47	26.41
50-59	21	11.80
60 above	19	10.67
Total	**178**	**100**
Location		
Rural	111	62.36
Urban	67	37.64
Total	**178**	**100**
Education Level		
No formal	12	6.74
Primary	8	4.49
Secondary	20	11.24
Tertiary	138	77.53
Total	**178**	**100**
Occupation		
Farming	62	34.83
Business	23	12.92
Civil servant	40	22.47
Student	17	9.55
Artisan	6	3.37
Others	30	16.86
Total	**178**	**100**

The education levels of the participants ranged from no formal education to tertiary level. The majority of the participants who use and harvest medicinal plants were found to be at the tertiary education level, representing 77.53% (n = 138). This observation is probably because of increased awareness and the desire to personalise their healthcare needs, leading to lifestyle choices.

Participants within the secondary school level covered 11.24% (n =20). The combined percentage of participants with no formal education and only primary education level was 11.24% (n = 20). While this study recorded a direct relationship between higher education level and harvesting and usage of medicinal plant resources, Omonona et al. (2012) observed an inverse relationship between higher education and usage of medicinal plants in Oyo metropolis.

Considering the occupation of participants, majority of them were farmers 34.83% (n = 62), followed by civil servants 22.47% (n = 40), those who do business account for 12.92% (n = 23), others accounted for 16.86% (n = 30) while students and artisans account for 9.55% (n = 17) and 3.37% (n = 6) respectively. Most farmers reside in rural areas and have more access to medicinal plants, with limited access to healthcare facilities, which could be possible explanations for the observations in this study.

3.2.1 Correlation between harvesting risks (HR) and relative abundance (RA) of medicinal plant resources in the study area

In order to assess the significance of the ecological impact of harvesting risk on the vulnerable species in the study area, the correlation between harvesting risk (HR) and relative abundance (RA) of the medicinal plants identified from the sampled plots was evaluated (Table 5).

Table 5 Spearman's Rank Correlation between HR and RA/ha (%)

Variable	HR	RA/ha (%)
HR	1.000	-0.398
RA/Ha	-0.398	1.000
Sig. (2-tailed)	-	0.127
N	16	16

Table 5 illustrates Spearman's rank correlation between harvesting risk (HR) and relative abundance (RA/Ha %). From the result, a negative correlation (p = -0.398) exists between harvesting risk (HR) and relative abundance (RA). This result implies that an increase in HR results in a decrease in RA/ha (%). Furthermore, the relationship is not statistically significant (p = 0.127 > 0.05) as observed from the sixteen medicinal plant species. This study found root and whole plant removal to be (26.042%). For communities that greatly depend on wild harvesting, with most of their medicinal plant resources being moderate-to-highly vulnerable, this implies susceptibility to pressures. Vulnerable species have wide application in traditional medicine with low abundance in their natural habitat (Ngamsou et al., 2024). Although only one of the plant species documented in the study area has a global vulnerability concern in the IUCN Red List (IUCN, 2025), and there is no statistically significant correlation between harvesting risks and relative abundance of species in their habitat (p = 0.127 > 0.05), the (56.25%) medium-to-high vulnerability observed in this study is an indication of local threats and the possibility of extinction is difficult to ignore in these communities.

3.3 Determination of the socio-economic factors influencing the use of medicinal plant resources in the study area

Multiple regression analysis is used to assess the socio-economic factors responsible for the use of medicinal plant resources in the study area.

Table 6: Regression table for the factors influencing the use of medicinal plant resources within the study area

Variable	Coefficients	Standard Error	t Stat	P-value
Intercept	0.925993	0.594917	1.556507	0.121458
Age	-0.02554	0.0625	-0.40866	0.683303
Gender	-0.06052	0.124614	-0.48567	0.62783
Education Level	0.01724	0.093313	0.184754	0.853643
Occupation	-0.06954	0.042698	-1.62865	0.10525
Location	-0.0313	0.137787	-0.22719	0.820547
Preference	0.286332	0.057722	4.960517	1.7E-06***
Accessibility	0.131455	0.065489	2.007274	0.046314**
Affordability	0.20567	0.070059	2.93569	0.003792***
At 1%	< 0.01	***	Multiple R	0.542
At 5%	< 0.05	**	R Square	0.294
At 10%	< 0.10	*	Adjusted R Square	0.260
F-value (8.812)	4.8E-10	***		

Table 6 showed the factors influencing the use of medicinal plant resources within the study area. The computed multiple R, having a value of 0.542 (54%), implied a strong positive relationship or correlation between the use of medicinal plant resources in the study area and factors such as preference over modern medicine, accessibility, and affordability. The coefficient of determination, R-squared at 0.294, implies that 29% of the proportion of the variance of factors influencing the use of medicinal plant resources in the study area is captured and explained by the independent variables in the model, whereas 71% remains uncaptured by the model due to other factors not captured in this study. An F-value of 8.812 (4.8E-10) was significant at 1% (p < 0.01), implying that the entire model is fit for the data used.

Preference as a factor is a significant determinant influencing the use of medicinal plant resources in the study area (coefficient = 0.286332; p = 0.0000001). With a positive coefficient and probability level less than 0.01, this implies that residents who exhibit a high preference level for medicinal plants over Western medicine mostly use them. This finding aligns with the study of Tengku et al. (2019) on the preference, perception, and predictors of usage of herbal medicine among women in Malaysia, where respondents cited safety and effectiveness as reasons for preference for plant resources over modern medicine for healthcare needs. In another study to understand the determinants of medicinal plants usage in Ibadan, Nigeria (Ariyo & Ariyo, 2018), the result of the study showed a significant positive correlation for preference for medicinal plants as a result of traditional beliefs. In this study, respondents believe that medicinal plants are holistic with multiple benefits and natural, which explains the high level of preference observed in the study. This is also the observation of (Mapunda & Mramba, 2025; Omonona et al., 2012). Both studies observed increasing preference for medicinal plants, especially in areas with limited access to modern healthcare. According to Guèze et al. (2014), even though there has been well-documented ethnobotanical knowledge of people in the tropical forest, there is still limited understanding as to why people show preference for some species over others and whether species abundance has a relationship with its use value.

The coefficient of accessibility is positive (0.131455) and statistically significant with a p-value less than 0.05 ($p = 0.046$). Accessibility is considered an influencing factor since people only use what they see as easy to access at any time. The more access to medicinal plants, the more their usage. This is consistent with the findings of Ariyo and Ariyo (2018), where nearness to forest showed a significant relationship with usage of medicinal plants. With farming as the major occupation of the respondents who mostly reside in the rural area (Table 4), this observation is not surprising, as farmers are in constant interaction with their environment and probably prefer to align themselves with nature rather than endure the stress associated with going to distant healthcare facilities. According to Mapunda and Mramba (2025), scarce and inaccessible healthcare outlets and services allow the use of accessible medicinal plant resources since these plants have long stood traditional uses for treatment of diseases.

At a p-value of 0.003, a positive coefficient of 0.20567, affordability as a factor is statistically significant ($p < 0.01$). By implication, the more affordable medicinal plants are, the more residents will want to patronize their use. The majority of the people in the study area are rural farmers, who are among the low-income earners (Table 3). Medicinal plants are cheap and provide them with an affordable option for their healthcare needs. This result indicates the likelihood of patronage of medicinal plants for economic reasons.

Other factors such as age, gender, education level, occupation, and location, although not statistically significant at any probability level, do not imply that they do not contribute to the determinants of medicinal plant use. They may do so indirectly, still influencing the choice of medicinal plant use within the study area. The observations of statistical significance in accessibility and affordability in the study area could have enabled equal opportunities across these factors.

3.4 Determination of the major threats to the ecological sustainability of medicinal plant resources in the study area.

In order to determine the most severe threats to commonly used medicinal plant species in the study area, ranking of threats (anthropogenic and natural pressures) was assessed based on knowledge of key informants in the communities. For this objective, ten key informants were requested to rank threats to medicinal plant sustainability in the study area using a scale of one to five (1= least and 5 = highest). The result is presented in Table 7.

Table 7: Direct Ranking of Threats to Medicinal Plants in the Study Area by Ten Key Informants (P1-P10)

Threats	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Total	Rank
Agricultural expansion	5	5	4	5	5	5	5	4	5	4	47	1
Charcoal production	2	4	2	4	3	4	2	4	3	3	31	4
Destructive harvesting	4	5	5	3	4	3	5	5	4	4	42	2
Overharvesting/Overgrazing	3	4	3	5	4	3	1	3	4	5	35	3
Climate change	1	3	4	1	3	1	5	4	3	5	30	5

The key informants ranked agricultural expansion and destructive harvesting as the greater threats facing medicinal plant resources, citing that almost every forest has now been encroached upon as a result of the growing number of people seeking land for agricultural purposes. It has also been observed that many people are harvesting medicinal plants destructively in the communities, thereby forcing some traditional medicine practitioners to begin cultivation of some species in their gardens. This is similar to the observations of (Asigbaase et al., 2023; Tadesse & Teka, 2022; Appiah et al., 2019), where agricultural expansion was observed to be the leading anthropogenic threat to medicinal plants loss and forest degradation. Plants generally are not uniformly distributed in their habitat, which implies that certain plants thrive only in specific microclimatic conditions. Once these conditions are disrupted through agricultural expansion, plants become exposed, leading to decline or extinction. Forest shrinkage due to agriculture can cause unhealthy competition for the few remaining medicinal plant species, which can lead to overharvesting or destructive harvesting of vulnerable species. As observed in this study, farming as the main occupation of the people in the study area has increased accessibility and influenced the use of medicinal plants. Most of the medicinal plants in the study area are vulnerable; destructive harvesting coupled with these threats has serious conservation implications for the medicinal plant species and, if not checked, could result in local extinction with huge consequences for the livelihood and healthcare needs of the people.

4 Conclusion

The findings of this study revealed that medicinal plants in the study area are under active threats. Destructive harvesting has shown immense contribution to the vulnerability and decline of medicinal plant resources observed in the study. The study concluded that comprehensive conservation interventions and sustainable harvesting practices are needed to prevent possible local extinction. The following recommendations are made based on the findings of this study:

i. There is a need to educate the communities on sustainable harvesting techniques such as selective pruning and limited leaf and root harvesting
ii. Farmers and traditional medicine practitioners should be encouraged to integrate highly demanding and vulnerable species of medicinal plants in their farms and gardens to reduce pressure on the wild population.
iii. It is necessary to conduct workshops and awareness campaigns in the study area to inform the people about how their unsustainable harvesting practices have led to high vulnerability of common medicinal plants in their communities, and the importance of conservation of these species.
iv. The study also recommends control of agricultural expansion and establishment of protected areas, which should be managed by the members of the communities to encourage local participation.
v. Further research and documentation of indigenous knowledge and practices should be conducted to identify conservation challenges and to develop strategies for sustainable utilisation of medicinal plant resources in the study area.

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