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Ethnobotanical documentation and conservation assessment of medicinal plants in the Bojanala District, North-West Province, South Africa

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Abstract

Background Bojanala District in North-West Province of South Africa is home to a diverse array of plant species, many of which are known for their medicinal properties. Despite their historical use, the pharmacological properties of these plants remain largely unexplored. The current study aimed to explore the phytomedicinal practices in Bojanala District by documenting medicinal plants and the associated indigenous knowledge.

Methods An ethnobotanical survey was conducted across six communities within the district between October 2024 and March 2025. Data were collected from 37 indigenous knowledge holders via face-to-face interviews using semi-structured questionnaires. The study followed purposive and snowball sampling methods. Data was then analyzed using ethnobotanical indices including Use Value (UV), Fidelity Level (FL), and Plant Part Value (PPV).

Results A total of 51 plant species from 28 families were documented, with Asteraceae (7 species) and Fabaceae (6 species) most represented. The most cited species were *Artemisia afra* (UV = 1.108), *Dicoma anomala* (0.622), *Siphonochilus aethiopicus* (0.459), *Drimia sanguinea* (0.459), and *Hypoxis hemerocallidea* (0.405). Twenty species, including *Artemisia afra* and *Bidens pilosa*, had an FL of 100%. Leaves (PPV = 0.329), roots (0.237), and bark (0.118) were the most used parts, primarily prepared as decoctions (54%). For example, Musculoskeletal conditions were treated with 20 species. Although 63% of species are Least Concern, some are declining due to overharvesting, trade, and habitat loss.

Conclusion Bojanala District retains extensive indigenous knowledge of medicinal plants, crucial for primary healthcare. Given population declines in some species, continuous monitoring, sustainable harvesting, and pharmacological validation of key species are recommended to support traditional use and guide the development of plant-based therapeutics.

Keywords North-West Province, Traditional medicine, Medicinal plants, Primary healthcare, Conservation status

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Background

Herbal medicine, also known as phytomedicine, is one of the oldest and remains among the most widely used systems of medicine worldwide [1, 2]. It involves the use of herbs or plant-derived materials for the prevention and treatment of various ailments, for the promotion of overall health. Before the introduction of orthodox medicine, traditional medicine constituted the sole healthcare system available to local communities [3, 4]. However, during the colonial and apartheid period in South Africa, the ruling authorities aimed to eradicate African Traditional Medicine (ATM), denouncing such practices as witchcraft, superstition, and magic, and also enforcing prohibition on their use among the indigenous communities [3, 4]. Despite these historical constraints, ATM has persisted and continues to play an important role in healthcare delivery across many parts of South Africa. In fact, some people still prefer herbal medicine over modern Western medicine because they believe it is more effective, calling it "*original medicine*" [5]. In addition, traditional medicine is preferred due to its cost-effectiveness, ease of access, and availability [2, 3, 6]. The abovementioned factors, together with the search for sustainable alternatives to western medicine, have resulted in a renewed interest and appreciation for traditional medicine systems [7–9]. According to Malerba [10], Some medical treatments have limited effectiveness or are associated with side effects, and the cost of quality healthcare has continued to increase over time.

Ethnobotany studies how people use and interact with plants, particularly in traditional medicine and its relevance to modern healthcare [11]. The foundation of ethnobotany lies in the indigenous knowledge that communities have gained through many generations of continuous engagement with the natural environment [12–14]. This knowledge underpins local decision-making on livelihoods, including health care, food production, and adaptation to social and environmental change. It varies across cultures and is traditionally transmitted orally from generation to generation [15, 16]. However, this knowledge is fast disappearing due to technological advancements**,** globalization, cultural changes among ethnic groups, and a lack of interest among youth [17–19]. Ethnobotanical research plays a crucial role in preserving indigenous knowledge by providing a systematic approach for documenting this knowledge for future generations [20]. Furthermore, ethnobotanical and ethnomedicinal studies are valuable tools for identifying new medicinal plants and re-investigating previously documented plants to further explore them. Despite advancements in modern medicine, traditional medicine continues to play a significant role in many people's lives.

South Africa has a rich biodiversity of more than 30 000 plant species, of which more than 3000 are used for medicinal purposes [21]. Numerous studies have documented the use of medicinal plants in various parts of South Africa, including Limpopo Province [18, 22–26], KwaZulu-Natal [27–31], and the Eastern Cape [32–34]. However, there is very limited documentation in the North-West Province [35–37]. Previous studies conducted in this province have largely focused on specific categories of ailments. For instance, Asong, et al. [38] documented plants used to treat skin-related conditions, Moroole [35] explored plants used as contraceptives and Ndhlovu, et al. [36] investigated those used to manage childhood illnesses. While these studies have made significant contributions to understanding the therapeutic applications of plant species in the province, they remain condition-specific in scope. Contrarily, this study adopted a broader approach of exploring medicinal plant use for general health management and the treatment of a wide range of ailments in Bojanala District. This study addressed the question of "what medicinal plants are used for the treatment of various health conditions in Bojanala District?" This study aims to fill this knowledge gap and to contribute to broader ethnopharmacological and conservation priorities by identifying species and knowledge systems that require further validation and preservation.

Materials and methods

Study area

This study was conducted across six communities (−25°38′04"S, 27°44′52"E) in the Bojanala District of North-West Province, South Africa (Fig. 1). The selected communities were Legonyane, Jericho, Maboloka, Letlhabile, Oskraal and Hebron. Bojanala District is one of the four districts in the North-West Province, subdivided into five local municipalities, namely: Kgetlengrivier, Kotane, Madibeng, Moretele and Rustenburg. The district covers an area of 18 333 km^2 and boasts a population of approximately 1,848,133, of whom 52.8% are males and 47.2% are females [39]. Ninety-four percent (94%) of district's population are Black Africans, 5% are white and 1% are colored and the dominant ethnic group (55.3%) is Setswana-speaking people [40]. Fifty-nine percent (59%) of the population is aged between 18 and 64 years [39]. There are approximately 501 696 households in the district, and over 50% are living in poverty [41]. In addition, reports from the North West Provincial Government [42] reveal that Bojanala District Municipality ranks first in the North West Province with an unemployment rate of 50.5%. According to Willie and Maqbool [43], there is a correlation between high unemployment rates and high poverty levels in impoverished communities, and these communities frequently lack resources. Due to factors such as unemployment, people lack the economic means

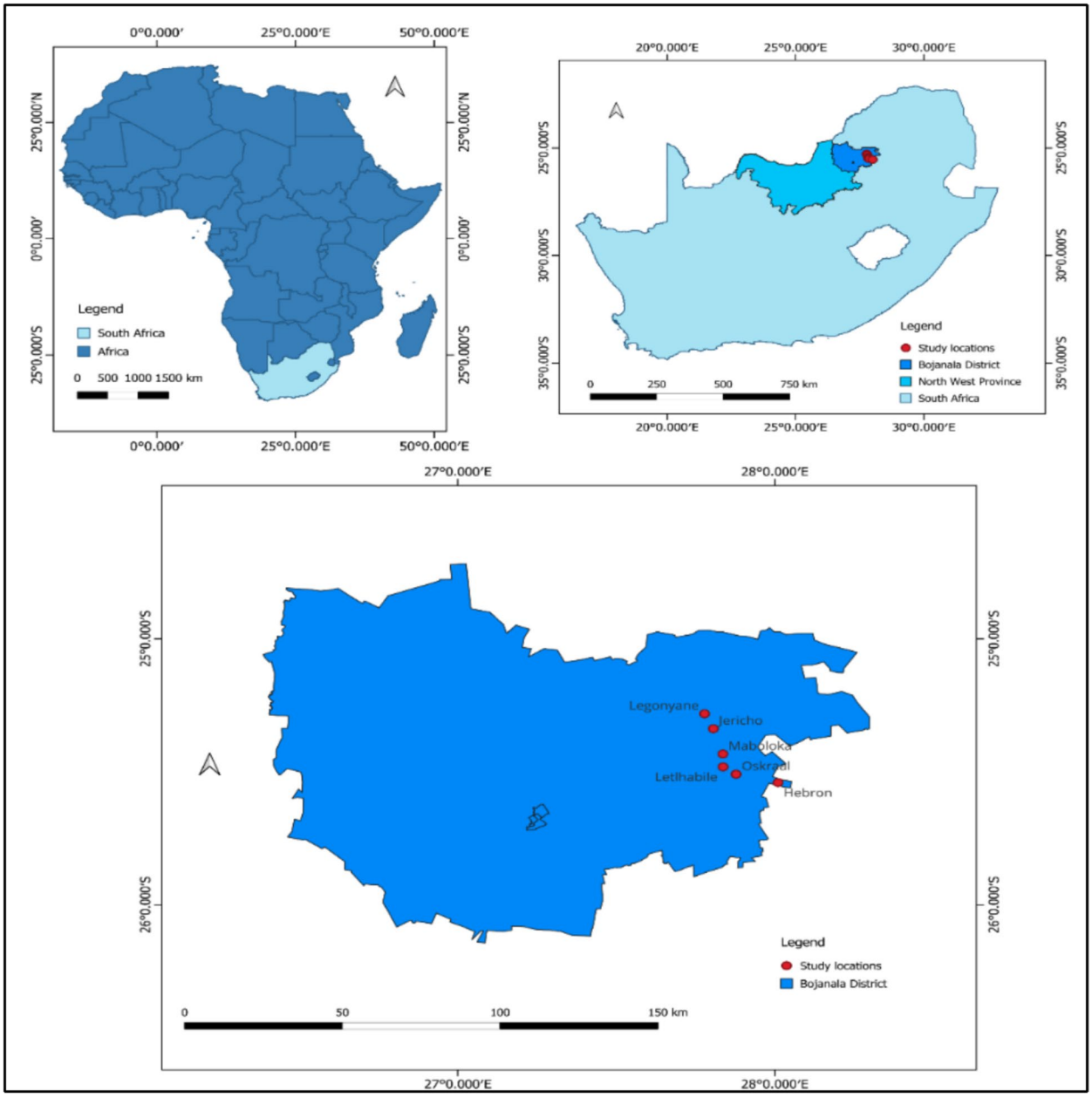

Fig. 1 Map of study locations in Bojanala District, North-West Province, South Africa. The map was generated using the free software QGIS version 3.40.12-Bratislava (available at www.qgis.org)

to pay for treatments and supplies, and they lack transportation to distant facilities.

Bojanala District is a central Bushveld area of the Savanna biome, which includes 22 vegetation units. Its vegetation mainly consists of thorny woodlands dominated by *Vachellia* Species, which can be dense or open with a herbaceous layer consisting of grasses and forbs [41]. Additionally, the area lies between 1000 and 1500 m above sea level and experiences high summer rainfall, with dry, frosty winters [40]. It receives about 550–650 mm of rain per annum and has an average maximum temperature of 36.7 °C. Large parts of this district are characterized by high levels of biodiversity, and it is home to various ecosystems and protected areas such as Borakalalo Nature Reserve, Hartbeespoort Dam Nature Reserve and Magaliesberg Protected Environment which also contribute to the region's biodiversity. This suggests an abundance of plant species, many of which are likely to have traditional uses. However, industry activities in the area such as mining and agriculture, have the potential drive rapid urbanization, which might adversely affect local biodiversity [44].

Sampling technique

Purposive sampling was used to identify key participants with specific knowledge of traditional medicine and indigenous knowledge systems. This sampling technique involves the intentional selection of individuals possessing characteristics or expertise relevant to the research or topic [45, 46]. This sampling technique is widely used in ethnobotany [47, 48], where the researcher relies on their judgment to select participants likely to provide rich and meaningful information for the study. Thus, the inclusion criteria for this study include individuals residing in the study area, aged 18 years and above, and indigenous knowledge holders from local communities who use phytomedicine. Individuals under 18 years of age were excluded from the study according to South African law [49], which classifies them as minors who cannot give consent on their own. In addition, a snowball sampling technique was used to identify and recruit traditional health practitioners and other knowledge holders. Snowball sampling is a recruitment technique in which initial participants refer additional participants from their own social networks who share relevant characteristics [50]. With this technique, the researcher begins by identifying a few initial participants who meet the study criteria. These participants then suggest others in their network who might also be relevant [50]. The process continues like a snowball, with the sample growing organically through referrals.

According to Rosenthal [51], the sample size in qualitative research should be sufficiently large to explore the phenomenon under investigation, but it should also adhere to the principle of saturation, the point in the data collection process at which no new insights are identified [52]. Although Keshoofy, et al. [53] contend that there is no agreement on the minimum sample size for qualitative research, data saturation and adequacy are the foundational elements for determining the qualitative sample size. Data saturation was reached when repeated plant species were recorded and no new ailment categories emerged, indicating that a sufficient sample size had been attained. Consequently, data collection was concluded after interviews with 8 key participants (traditional health practitioners) and 29 regular participants (Indigenous knowledge holders), yielding a total sample size of 37 (Table 1).

Table 1 Sociodemographic characteristics of participants ($n = 37$)

Variable	Frequency	Percentage (%)
Gender		
Male	10	27.0
Female	27	73.0
Age (years)		
18–30	2	5.4
31–40	7	18.9
41–50	15	40.5
51–64	5	13.5
65 +	8	21.6
Marital status		
Single	16	43.2
Married	14	37.8
Divorced	2	5.4
Widowed	5	13.5
Education level		
Uneducated	1	2.7
Primary school	2	5.4
Secondary school	20	54.1
Tertiary	14	37.8
Employment status		
Unemployed	9	24.3
Self-employed	4	10.8
Employed	15	40.5
Retired	9	24.3
Participant category		
Key participants	8	21.6
Regular participants	29	78.4

Data collection

Ethnobotanical data was collected between October 2024 and March 2025. To enhance the depth and accuracy of the data, follow-up interviews with key participants were conducted from April -June 2025. Data was primarily collected through in-depth, face-to-face interviews with 37 participants, using semi-structured questionnaires. The questionnaire used was developed by the researcher specifically for this study; some questions were adapted from Latif [54]. The interviews were conducted in the participants' homes, at herbal vendors, also known as "muti shops", and in consulting rooms, "indumba". Semi-structured interviews were chosen because they allowed the researcher to ask follow-up questions and probe for clarification of unclear responses. Interviews were audio-recorded with consent and manually transcribed. When language differences occurred, local interpreters assisted, and all transcripts were cross-checked for accuracy. All plant species mentioned during interviews were targeted for voucher specimen collection to ensure taxonomic verification. Where possible, plant specimens were collected in the field and from home gardens in the presence of participants to confirm local names and species identity, and the names were validated using the PlantZA database (https://pza.sanbi.org/). For species where fresh specimens were unavailable, photographs were taken to support identification, and ethnobotanical literature [36, 55] was consulted. A plant collection permit was obtained from the North-West Department of Economic Development, Environment, Conservation and Tourism. Collected specimens were dried, pressed, assigned voucher numbers, and deposited at the Indigenous Flora

Research Lab, University of Mpumalanga, where Dr. Luambo Jeffery Ramarumo authenticated them. Botanical names were verified using authoritative databases, including the South African National Biodiversity Institute (SANBI) PlantZAfrica database (https://pza.sanbi.org/), World Flora Online (https://www.worldfloraonline.org/), and Plants of the World Online (POWO) (https://powo.science.kew.org/), following the APG IV classification system. Conservation status was assessed using the SANBI Red List of South African Plants.

Quantitative ethnobotanical data analysis

We applied four ethnobotanical indices, including Use Value (UV) [56], Fidelity Level (FL), Plant Part Value (PPV) [57], and Informant Consensus Factor (ICF) [58, 59], to provide complementary insights into the ethnobotanical data. The Use Value measures species importance based on reported uses, FL indicates agreement among participants on specific uses, PPV reflects each plant's contribution to medicinal or cultural values, and ICF assesses consensus within ailment categories. Together, these indices enhance analytical depth and provide a comprehensive understanding of ethnobotanical patterns. Data were analyzed using frequencies and percentages, and the indices were applied following the formulas below [58, 59].

Fidelity level (FL) indicates participants' preference for particular plant species to treat a specific disease. It was calculated following Zent [60], using the given formula (1):

$$FL\% = \frac{N_p}{N} \times 100 \quad (1)$$

where FL refers to the fidelity level of the species, Np stands for the number of participants reporting use of particular plant species for a specific disease category, and N = total number of participants who mentioned uses for a specific plant species for all disease categories. According to Kayani, et al. [61], A high FL value shows the maximum frequency of use by the participants to treat a particular disease.

Use Value (UV): Use value marks the relative importance of different uses of the species. It was determined using a formula cited in the past, following the protocol of other researchers who have previously used the same formula [62].

$$UV_i = \frac{\sum U_i}{N} \quad (2)$$

where: UV_i refers to the relative use value of the species, U_i is the number of uses mentioned by each participant and N stands for the total number of participants who reported the species [63].

Informant consensus factor (ICF) is an approach that relies on informant consensus regarding plant species and their applications, with the intention to connect a high level of consensus with the usefulness of the species [36, 64, 65]. It was calculated using the following equation:

$$ICF = \frac{Nur - Nt}{Nur - 1} \quad (3)$$

where: Nur stands for the number of use reports for a particular ailment category and Nt refers to the number of plant species used for treating that reported ailment.

Plant part value (PPV): Plant part value (PPV) is used to show the use frequency of each plants part [57, 66]. The part with the highest PPV is the most used part by participants. It is calculated as follows:

$$PPV = \frac{RU_{plantpart}}{RU} \quad (4)$$

where: PPV stands for the plant part value of a species, $RU_{plant\ part}$ refers to the sum of uses reported for a specific part of the plant, and RU is the number of uses reported for all parts of the plant [67].

Ethical statement

Before conducting the study, ethical clearance was obtained from the University of Mpumalanga research committee (*UMP/Matlala 220,207,089/SBES/MSc/2024/1*). The researcher also obtained approval to collect data from traditional health practitioners through the Traditional Health Practitioners Organization (THO) and from community members through the Bakwena ba Mogopa Tribal Authority. During data collection, all participants were given an information leaflet with a consent form attached. The researcher explained the contents of the information leaflet to the participants, making them aware of the study's details, aims, and objectives, and the expectations of the researcher and the participants. The researcher also informed the participants that their participation was voluntary, that no one would be forced to participate, and that they had the right to terminate their participation even after signing the consent form. Ethical principles applied in this study included the principle of anonymity, which ensured the confidentiality of participants' identities. The principle of respect was also applied, as all participants were treated with utmost respect.

In line with ethnobiological ethics and the Nagoya Protocol on Access and Benefit-Sharing, the findings will be shared with participating communities via workshops

and summary reports in local languages. A copy of the study will also be submitted to the Provincial Department of Health, as required by the approved ethical clearance. Furthermore, capacity-building on plant conservation and sustainable use will be promoted, and any future research or commercialization will occur only with prior informed consent and agreed benefit-sharing.

Results and discussion

Sociodemographic characteristics of participants

This ethnobotanical survey included 37 participants from six communities in the Bojanala District, representing a range of ages, genders, marital statuses, education levels, and employment statuses. A majority of participants were female, most were in the 41–50 years age group, and over half were employed. Table 1 provides a detailed summary of the participants' sociodemographic information. According to Ramarumo [68] and Howard [69], there is an uneven distribution of understanding of how plant species are used in indigenous knowledge between genders. The differences in gender regarding this understanding are associated with activities that men and women participate in, influenced by socially constructed and defined roles. Generally, women are considered primary caregivers in families and communities because they are responsible for food preparation, childcare and general household health. Contrarily, men are presumed to be leaders, breadwinners and protectors, with less exposure to the domestic sphere where medicinal knowledge is practiced. As a result, women have always possessed more knowledge than men about plant utilization, as this knowledge is required for their daily activities [69–71]. The findings of this study are similar to previous studies that found women are better informed about plant utilization than men [71–75]. On the other hand, Tadesse, et al. [76] and Yimam, et al. [77] found that men were more knowledgeable than women.

Intergenerational knowledge transfer

In this study, the percentage of knowledgeable participants was lower among younger generations.

(18–30 and 31–40 age categories) and in the elderly (51–64 and 65 + years old). These findings are similar to those of other studies, which found a decline in possession of indigenous knowledge among younger generations [17, 78]. This could be attributed to factors such as urbanization; migration and technological advancements. For instance, recently, many people, particularly youth, have moved from villages and rural areas to cities and towns in search of new opportunities.

[47]. While these opportunities are beneficial, they can also lead to a disconnect from traditional practices. This shift poses a significant risk to the continuity of knowledge that has sustained indigenous communities for years [79]. Additionally, this study revealed a decline in older adults' knowledge of phytomedicinal use, which could be due to the aging of the community [17, 47]. This threatens the transmission of knowledge to younger generations, affecting skills, healthcare, agriculture, cultural identity, and environmental management, while increasing reliance on pharmaceuticals and contributing to biodiversity loss and environmental degradation [80].

Attainment of formal education and employment among participants

Table 1 shows that the majority of participants in this study attained secondary and tertiary level education, and less than 10% of the participants did not receive any formal education. This is contrary to findings from other studies, where many participants had low levels of formal education attainment [47, 81, 82]. Previous studies have indicated that people who know or use traditional medicine are generally have low levels of formal education, while highly educated people are likely to have minimal indigenous knowledge and would therefore prefer modern medical technology to indigenous knowledge [81]. In this study, the majority of participants received formal education and these findings were supported by Mander, et al. [83] and Mmamosheledi and Mncengeli [5], reported that traditional medicine practice is not limited to underprivileged people living in remote areas or those lacking education. Additionally, over 50% of the participants in this study were employed and received an income. Twenty-four percent (24%) of participants were retired and the other 24% were unemployed. As mentioned by Hughes, et al. [84], and Otang-Mbeng, et al. [85], traditional medicine is used by people from all social groups and classes, irrespective of age, level of education, religious affiliation or occupation.

Botanical diversity and use of medicinal plants

Medicinal plant species used in the study area belonged to twenty-eight (28) families, and Asteraceae was the most common plant family with seven species, followed by Fabaceae with six species, Anacardiaceae with four species, Asphodelaceae and Euphorbiaceae with three species each (Table 2, Fig. 2). These findings align with previous South African studies, which also identified Asteraceae, Fabaceae, Euphorbiaceae, and Asphodelaceae as dominant families in traditional healthcare [27, 86–88]. In addition, the updated list of medicinal plants of Southern Africa reveals that, except Anacardiaceae, these form part of the top 10 medicinal plant families in Southern Africa [89]. Unsurprisingly, that Asteraceae and Fabaceae are among the commonly used medicinal plant families because they are some of the largest families globally.

Table 2 Inventory of medicinal plants used by in Bojanala District, North-West Province, South Africa

Family	Scientific name Voucher no	Common name	Plant form[a]	Ailment treated/Use	PPU[b]	Method of preparation	Administration & Dosage	N[c]	UV[d]	Cs[e]
Aizoaceae	*Carpobrotus × accedens* B.P.R.Chéron **MEM 001**	Mochips (Tswana)	Cr	Tonsils, used as an anti-inflammatory	Whole plant, leaves	Crush and add into water or squeeze the juice into the mouth	Oral consumption Gargle as needed	2	0.081	LC
	Sceletium tortuosum L. [syn. *Mesembryanthemum tortuosum* L.] **MEM 51**	Kanna (Tswana)	Cr	Management of stress and anxiety	Flower, seed	Decoction Burning	Oral consumption Smoke inhalation 1 cup/day	2	0.081	LC
Amaranthaceae	*Beta vulgaris* subsp. *vulgaris* **MEM 003**	Beetroot (English)	H	Boost the immune system	Leaves, bulb	Decoction	Oral consumption Drink as needed	1	0.027	NE
	Dysphania ambrosioides (L.) Mosyakin & Clemants **MEM 004**	Motlhatlhabadimo (Tswana)	H	Gastrointestinal cleansing, treatment of hemorrhoids, constipation, and pediatric digestive ailments *(hlogwana ya bana)*	Leaves	Decoction Grind dried leaves and mix with snuff and grated green sunlight bar, roll into a small ball	Enema or insert the small ball into the anus Oral decoction Use as needed	4	0.135	NE
Amaryllidaceae	*Boophone disticha* (L.f.) Herb **MEM 051**	Legwama/ seipone (Tswana)	H	Non-healing surgical wounds, relief of chest congestion, and used in ancestral divination rituals	Bulb	Decoction	Oral consumption Drink ¼ cup 2 times a day	3	0.081	LC
	Allium cepa L **MEM 002**	Onion (English)	H	Feet cracks Blocked nose, tight chest	Bulb	Juicing (mix with baking soda and Vaseline) Infusion	Topically Steaming Apply as needed	2	0.081	-
Anacardiaceae	*Lannea schweinfurthii* (Engl.) Engl. var. *stuhlmannii* (Engl.) Kokwaro **MEM 050**	Molebatsi (Tswana)	T	Alleviates depression, calms the nervous system, and provides temporary relief from stress or trauma	Roots	Burning	Smoke inhalation As needed	4	0.135	LC
	Mangifera indica L **MEM 005**	Mango (English)	T	Management of *diabetes mellitus*, dysmenorrhea, and constipation	Leaves	Decoction	Oral consumption ½ cup 2 times per day	1	0.081	DD
	*Schinus polygama (*Cav.) Cabrera **MEM 006**	Monwametsi (Tswana)/mopepere (Pedi)	T	Respiratory conditions (Influenza, asthma, covid19), hematological support, and vaginal infections	Leaves, roots, bark	Decoction	Oral consumption Steaming ¼ cup 2 times/day	5	0.297	NE
	Sclerocarya birrea (A. Rich.) Hochst. subsp. *caffra* (Sond.) Kokwaro **MEM 007**	Morula (Tswana)	T	Sexually transmitted infections, post-miscarriage recovery, reproductive disorders, vaginal infections, hematological support, bereavement-related ailments, and to avert misfortune	Bark, roots	Decoction Infusion	Oral consumption, steaming and bathing ¼ cup 2 times/day	6	0.162	LC

Table 2 (continued)

Family	Scientific name Voucher no	Common name	Plant form[a]	Ailment treated/Use	PPU[b]	Method of preparation	Administration & Dosage	N[c]	UV[d]	Cs[e]
Asparagaceae	*Asparagus suaveolens* Burch **MEM 049**	Lesitlwane/ Mfahla-namane (Tswana)	S	Pediatric digestive ailments *(hlogwana ya ngwana)* and ocular disorders	Roots	Decoction	Steam for hlogwana Take orally for eye problems ½ cup during the day & 1 cup at night	2	0.054	LC
	Drimia sanguinea (Schinz) Jessop **MEM 024**	Sekaname (Setswana)	H	Hypertension, gastro-intestinal disorders, hematological and renal support, uterine cleansing, erectile dysfunction, vaginal infections (*sebabo*/ bacterial vaginosis), as well as alleviating back pain, paresthesia, and cultural ailments such as misfortune	Bulb	Decoction Infusion	Oral consumption and bathing Drink 3 cups/day	9	0.459	NT
	Eucomis autumnalis (Mill.) Chitt **MEM 048**	Mathubadifala (Setswana)/ Mathunga (isiZulu)	H	Post-miscarriage uterine recovery, hematological support, and internal healing of surgical wounds	Whole plant, roots	Decoction (mix with a bit of holy ash)	Oral consumption 1 cup every morning	4	0.108	LC
Asphodelaceae	*Aloe marlothii* subsp. *Marlothii* **MEM 008**	Kgopane (Tswana)/ Sekgopha (Pedi)	Su	Vaginal infections (*sebabo*/bacterial vaginosis), dermatological conditions (rash, alopecia), diabetes, hypertension, arthritis, abscesses, wound healing, immune support, grief-related ailments (sefifi), and poisoning	Whole plant	Blend the gel	Topical application, oral consumption Bathing Take 1 tablespoon of gel in 1 cup of water 3 times/day	4	0.270	LC
	Aloe davyana var. magdae Gideon F.Sm **MEM 009**	Aloe (English)	Su	General ailments, poisoning, hangover, edema and leg pain, weight management, and acne	Leaves	-	Oral (chew), bath, or apply topically Use as needed	3	0.135	LC
	Aloe vera (L.) Burm.f **MEM 010**	Lekgala (Tswana)	Su	Hair breakage, dandruff, dermatological conditions (acne, eczema), and bile reflux (*go ntsha gala*)	Whole plant	-	Topical application Use as needed	3	0.135	LC

Table 2 (continued)

Family	Scientific name Voucher no	Common name	Plant form[a]	Ailment treated/Use	PPU[b]	Method of preparation	Administration & Dosage	N[c]	UV[d]	Cs[e]
Asteraceae	*Artemisia afra* Jacq. ex Willd **MEM 011**	Lengana (Setswana)	S	Respiratory conditions (COVID-19, colds, influenza, asthma, bronchitis, sinusitis, tight chest, pollen allergies, TB), boost immunity, and manage gout and heartburn	Leaves, flowers	Decoction	Oral consumption and steaming Drink ½ cup 2 times/day	21	1.108	LC
	Bidens pilosa L **MEM 012**	Sepodisi/ Maphodisa (Setswana)	H	Toothache	Roots	Decoction	Oral consumption Drink or gargle with ½ cup of the decoction	2	0.054	NE
	Dicoma anomala subsp. *gerrardii* (Harv. ex F.C.Wilson) S.Ortiz & Rodr. Oubiña **MEM 047**	Tlhonya (Setswana)	S	Influenza, fever, rash, persistent cough, blood disorders, and gastrointestinal ailments	Roots, leaves, stem	Decoction Infusion	Oral consumption Drink 3 cups/day, as needed	16	0.622	NT
	Helichrysum caespititium (DC.) Harv **MEM 046**	Phate ya ngaka (Setswana)	H	Treat influenza and coughs, and for ritual purposes to invoke ancestors	Leaves, flowers	Decoction Burn the dried parts	Oral consumption Smoke inhalation Use as needed	2	0.081	LC
	Helichrysum odoratissimum (L.) Sweet **MEM 013**	Impepho (isiZulu)	H	Treats common cold symptoms, Influenza, headaches/migraines	Whole plant	Decoction Burning	Steaming, smoke inhalation Use as needed	3	0.081	LC
	Kleina longiflora DC **MEM 014**	Mosiama (Setswana) (mali)/mmale (Sepedi)	H	Used for antidepressant, antimicrobial, musculoskeletal pain relief, fatigue, and wound healing	Leaves	Infusion poultice	Oral consumption, topical application and used for bathing Use as needed	2	0.216	LC
	Schkuhria pinnata (Lam.) Kuntze ex Thell **MEM 015**	Mpabane (Setswana)	H	Stomachache and diarrhoea	Whole plant	Crush and mix with water	Oral consumption 1 cup per day	4	0.162	NE
Capparaceae	*Cadaba aphylla* (Thunb.) Wild **MEM 045**	Monnamontsho (Setswana)	S	Headaches, migraines	**B**ark	Burning	Smoke inhalation Use as needed	2	0.054	LC
Cannabaceae	*Cannabis sativa* L **MEM 016**	Motekwane/ patje (Setswana)	H	Respiratory tract infections (asthma, influenza, COVID-19, pneumonia), headaches, and promotion of hair growth	Leaves	Decoction	Oral consumption, washing ½ cup/day	5	0.189	NE
Convolvulaceae	*Ipomoea oblongata* (E.Mey.ex Choisy) **MEM 044**	Ubhoqo (isiZulu)	H	Enhances female fertility, supports hematological health, and promotes weight gain	Leaves and roots	Cut into pieces, put in tap water and beat/mix until it creates a foam	Oral consumption	1	0.081	LC

Table 2 (continued)

Family	Scientific name Voucher no	Common name	Plant form[a]	Ailment treated/Use	PPU[b]	Method of preparation	Administration & Dosage	N[c]	UV[d]	Cs[e]
Euphorbiaceae	*Euphorbia prostrata* Aiton **MEM 017**	-	H	Used to treat shingles	Whole plant	Burn to ashes and mix with blue seal Vaseline and a bit of paraffin	Apply topically Use as needed	1	0.027	NE
	Manihot esculenta Crantz **MEM 018**	Mutumbula (TshiVenda)	S	Boosting the immune system, boosts fertility in men and women, arthritis	Tuber, leaves	Leaves can be cooked as morogo Leave decoction The tuber can be ground	Oral consumption (tuber can be eaten as a vegetable, cooked leaves can be eaten as morogo and the ground tuber can be used in porridge) Consume as you need	1	0.081	NE
	Ricinus communis L **MEM 019**	Mokhure (Sepedi)	S	Treatment of leg edema and pain	Leaves	Infusion	Use the leaves as "wash cloth" and wash the legs Use as needed	3	0.081	NE
Fabaceae	*Elephantorrhiza elephantina* (Burch.) Skeels **MEM 020**	Mosetlhana (young) (Setswana)/ ntolwane (isiZulu)	S	Immune support; treatment of erectile dysfunction, infertility, malnutrition, anemia, biliousness *(gala/ nyoko)*, influenza, and rash	Roots	Grind dried parts into fine powder Decoction	Oral consumption Add small amounts of the powder into porridge and consume as needed. The decoction can be drunk as purgative to induce vomiting "*go gapa*"	3	0.243	LC
	Peltophorum africanum Sond **MEM 021**	Mosetlha (old) (Setswana)	T	Stomachache, bloating, blood cleansing and cleansing after funerals (diseases that come to the bereaved)	Bark	Decoction Infusion	Oral consumption and used for bathing ½ cup 2 times/day	6	0.243	LC
	Senegalia caffra (Thunb.) P.J.H. Hurter &Mabb *Syn Acacia caffra* (Thunb.) Willd **MEM 043**	Poo-tshehla (Setswana)	T	Erectile dysfunction and headaches, migraines	Roots	Decoction	Oral consumption ½ cup when needed	3	0.108	LC
	Senna italica Mill. subsp. *arachoides* (Burch.) Lock **MEM 042**	Sebete/Morototshwetse (Setswana)/ Morotelatshoswane (Sepedi)	H	Sesepidi (abscess), gala (biliousness), blood and kidney cleansing, stomachache	Leaves, roots	Poultice Decoction Chew	Topical application, oral consumption Use as needed	4	0.135	LC
	Vachellia karroo (Hayne) Banfi & Glasso *Syn: Acacia karroo* Hayne **MEM 022**	Mosu (Sepedi)	T	Ringworm, stop vomiting	Stem and branches (gum), roots and thorns	Burn the stem or branches until you see gum at the end of the stick Decoction	Topical application Oral consumption	2	0.054	LC
	Vachellia xanthophloea (Benth) P.J.H. Hurter **MEM 023**	Mukhanyakude (isiZulu)	T	Purification and blood related conditions	Bark	Decoction	Oral consumption Drink ½ cup 2 times a day	1	0.054	LC

Table 2 (continued)

Family	Scientific name Voucher no	Common name	Plant form[a]	Ailment treated/Use	PPU[b]	Method of preparation	Administration & Dosage	N[c]	UV[d]	Cs[e]
Geraniaceae	*Monsonia angustifolia* E.Mey **MEM 041**	Tee ya thaba (Sepedi)	H	Renal and uterine support, erectile dysfunction, vaginal infections, and hematological support	Leaves	Decoction (mix with FG, treker and Joko)	Oral consumption Drink 1 cup of decoction as needed	2	0.135	LC
Hypoxidaceae	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Avé-Lall **MEM 025**	Tshuku ya poo/monna maledu (Setswana)	H	Hypertension, gastric ulcers, immune support, hematological and renal support, urinary tract infections, infertility, pediatric burn wounds, and erectile dysfunction	Bulb, flower, roots	Decoction Poultice	Oral consumption, topical application ½ cups 2 times/day	10	0.405	LC
Lamiaceae	*Mentha spicata* subsp. *spicata* **MEM 026**	Mint (English)	H	Asthma, bronchitis, Influenza, nausea, and sore throat	Leaves	Decoction	Oral consumption and steaming 1 cup 2 times a day or steam as you need	2	0.135	NE
Lythraceae	*Punica granatum* L **MEM 027**	Garenate (Setswana)	T	Toothache, stomachache, diarrhoea, stroke	Roots	Decoction	Oral consumption (rinse the mouth for toothache) Drink ½ cup when needed	7	0.243	NE
Moringaceae	*Moringa oleifera* Lam **MEM 028**	Moringa (Setswana)	T	Immune support, hematological health, management of diabetes and hypertension, respiratory conditions, and anti-inflammatory effects	Leaves, roots, seeds	Decoction Grind into fine powder	Oral consumption Drink 1 cup 2 times/day or a tablespoon of powder into porridge every morning	3	0.243	LC
Musaceae	*Musa acuminata* subsp. *errans* (Blanco) R.V.Valmayor **MEM 029**	Panana (Setswana)	T	Heart conditions, arthritis, painful and swollen feet	Flower, leaves, bark	Decoction Burn to ashes	Oral consumption or the ashes can be applied on incisions to get into the bloodstream	2	0.108	LC
Myrtaceae	*Eucalyptus camaldulensis* Dehnh **MEM 030**	Mobilikomo (Setswana)	T	Influenza, cough, COVID-19, asthma and other respiratory conditions, and musculoskeletal pain	Bark, leaves	Decoction	Steaming As needed	6	0.270	NE
	Psidium guajava L **MEM 031**	Moguava (Setswana)	T	Hypertension, menstrual cramps, used as an anti-inflammatory	Leaves	Decoction	Oral consumption	3	0.081	NE
Solanaceae	*Solanum aculeastrum* Dun **MEM 040**	Thola (Setswana)	T	Toothache and worm in the teeth/gums, Influenza	Roots	Decoction	Oral ½ cup per day or steam as much as needed	4	0.135	LC
Rhamnaceae	*Ziziphus mucronata* Willd. subsp. *mucronata* **MEM 032**	Mokgalo (Setswana)	T	Sesepidi (abscess), boils and ulcers (*diso ka mo gare*), blood cleansing, it is also used as a painkiller and antibiotic	Leaves, bark	Poultice Decoction	Topical application or oral consumption ¼ cup 2 times a day	6	0.297	LC

Table 2 (continued)

Family	Scientific name Voucher no	Common name	Plant form[a]	Ailment treated/Use	PPU[b]	Method of preparation	Administration & Dosage	N[c]	UV[d]	Cs[e]
Rosaceae	*Eriobotrya japonica* (Thunb.) Lindl **MEM 033**	Mmupudu wa sekgowa (Setswana)/ Loquad tree (English)	T	Hypertension and *diabetes mellitus*	Leaves	Decoction	Oral consumption 1 cup/day	2	0.081	-
	Prunus persica (L.) Batsch **MEM 034**	Perekisi (Setswana)	T	Diarrhoea, stomachache	Leaves	Decoction	Oral consumption	2	0.054	NE
Rubiaceae	*Pentanisia prunelloides* subsp. *latifolia* (Hochst.) Verdc **MEM 039**	Setimamollo (Setswana)	H	Rash	Roots	Infusion	Oral consumption or steaming	2	0.054	LC
Verbenaceae	*Lippia javanica* (Burm.f.) Spreng **MEM 035**	Mosunkwana (Setswana)	S	Persistent cough, colds, influenza, dizziness, and nasal congestion	Leaves	Decoction Burning	Oral consumption Smoke inhalation Steaming As needed	3	0.216	LC
Zingiberaceae	*Siphonochilus aethiopicus* (Schweif.) B.L. Burt **MEM 036**	Serokolo (Setswana)	H	Influenza, fever, umbilical cord care *(khubyana),* and go gatolla	Rhizome	Decoction Chew (then mix with Vaseline)	Oral consumption Topical application 3 cups/day	11	0.459	CE
	Zingiber officinale Roscoe **MEM 037**	Ginger (English)	H	Influenza and persistent coughs	Rhizome	Decoction	Oral consumption 2 cups/day	3	0.081	LC
Zygophyllaceae	*Balanites maughamii* Sprague **MEM 038**	Gobandlovu (isiZulu)	T	Kidney failure and erectile dysfunction	Bark, roots	Decoction	Oral consumption Drink ½ cup 2 times per day	1	0.054	LC

Decoction: a form of medicinal plant remedy prepared by combining parts of water with plant parts, boiled slowly till boiling point is reached, cooled, strained and ready for use

Infusion: is a form of remedy prepared by adding a quantity of fresh grounded or dried plant parts to a cup of boiled water, then the mixture is infused for few minutes, strained and used

Poultice: a form of remedy where fresh leaves or fleshy plants crushed into a paste and are applied to wounds, sores and other skin ailments

[a] *H* Herb, *T* Tree, *S* Shrub, *Cr* Creeper, *Su*: Succulent

[b] *PPU* Plant part used

[c] *N* Frequency of mention

[d] *UV* Use value

[e] *Cs* Conservation status, *LC* Least concern, *NE* Not evaluated, *DD* Data deficient, *NT* Near threatened, *CE* Critically endangered, "-": not specified: MEM = Voucher number

Asteraceae is one of the most well-known flowering plant families, with > 1600 genera and 25,000 species globally [90, 91], has many species that have been cultivated for culinary and therapeutic purposes for more than 3,000 years. These species are more common in arid and semi-arid areas of subtropical countries, and they display diverse anti- inflammatory, antibacterial, antioxidant, and hepatoprotective properties [90]. Asteraceae holds greater ethnomedicinal importance due to its versatility and widespread application in treating ailments such as respiratory infections and gastrointestinal disorders [92]. Their accessibility, rapid growth, and ease of harvesting further enhance their role in everyday household medicine [92].

Fabaceae, also known as Leguminosae, ranks as the third largest plant family after Asteraceae and Orchidaceae, comprising around 770 genera and 19,500 species globally [93, 94]. The majority of species within this family used in traditional medicine exhibit anticancer, antidiabetic, antifertility, anthelmintic, anti-inflammatory, antimicrobial, antioxidant, antiparasitic, cytotoxic, hepatoprotective, hypoglycaemic, and immunomodulatory properties [95]. The Fabaceae family is strongly associated with treatments for chronic conditions, reproductive health, and skin care, and many species of this family

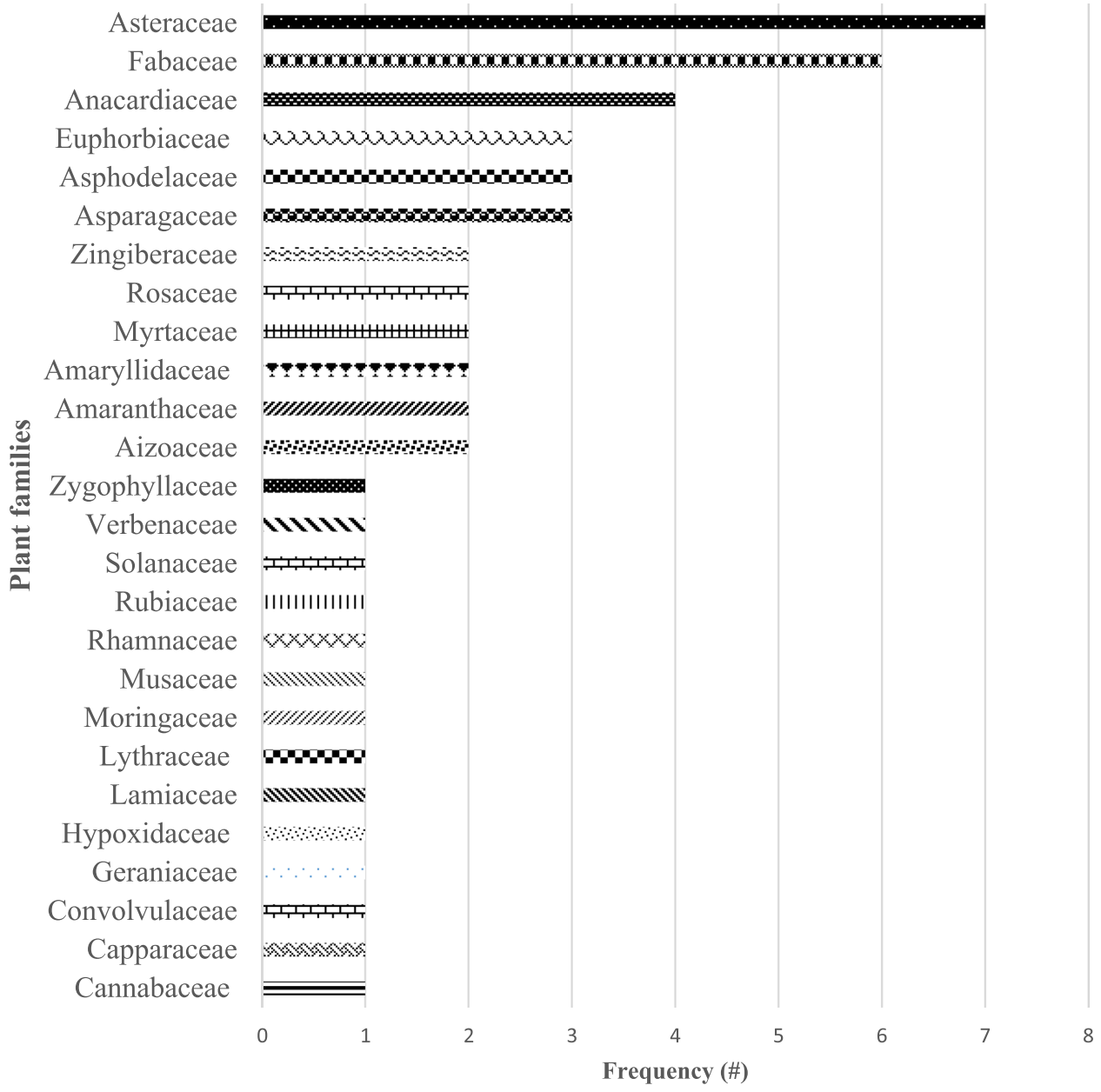

Fig. 2 Distribution of plant families used for medicinal purposes in Bojanala District, North-West Province, South Africa

are woody perennials, making them reliable year-round resources [96, 97]. On the other hand, Anacardiaceae has only about 700 species [98], but it still formed part of the most popular medicinal plant families in this study. Some species of this family possess bioactive compounds with antimicrobial, antifungal, immunological and antioxidant properties, which make them beneficial in traditional medicine [99]. In addition to their bioactive compounds, the popular use of the aforementioned plant families can also be attributed to the availability or cultural significance of species from those families in the study area [100]. The high number (52) of medicinal plant species mentioned in this study may be an indication of the region's rich traditional knowledge on medicinal plants.

Use value (UV)

In this study, use values ranged between 0.027–1.108 (Tables 2 and 3). Artemisia *afra* Jacq (1.108), *Dicoma anomala* (0.622) and *Drimia sanguinea* (Schinz) Jessop (0.459) had the highest UVs. *Artemisia afra* was mentioned by 21 participants for respiratory and gastrointestinal conditions, while *D. anomala* was mentioned by 16 participants for the same category of health conditions. Contrary to this, a study from Mpumalanga Province found *Elaeodendron transvaalense* (Burtt

Table 3 Illustration of how use values were determined *(example: Carpobrotus × accedens* B.P.R.Chéron*)*

Number of uses reported by participants	1	2	3	4	5
Number of participants who mentioned this number of uses	1	1	0	0	0
Total number of participants in the study	37				

$UV = (1 \times 1/37) + (2 \times 1/37) + 0 + 0 + 0 = 0.081$

Davy) R.H.Archer and *Merwilla plumbea* (Lindl.) Speta to have the highest use values [65]. These plant species were used in ailments such as fertility, boils, wounds, and heartburn. In the Eastern Cape Province, *Aloe ferox* Mill. and *Carpobrotus × accedens* B.P.R.Chéron had the highest use values, and they were used for conditions such as eczema, skin irritations, burns, insect bites, ringworm, boils, pimples, wounds and skin ulcers [101]. A high UV demonstrates that a particular plant is widely known, commonly used, and culturally salient within the community [36]. The popularity of such plant species can be due to the fact that most traditional health practitioners undergo similar training processes *"go thwasa"*. In addition, factors such as availability and accessibility of the species and the indigenous success may also influence the widespread of these species within the cultural traditions and primary healthcare systems in the local communities [36]. In this study, *Beta vulgaris* subsp. (0.027) and *Euphorbia prostrata* Aiton (0.027) had the lowest UVs. These species were only cited once, with *B. vulgaris* being used as an immune booster and *E. prostrata* being used to treat shingles.

Fidelity level (FL)

In this study, FL ranged between 4.76%–100%. A total of 20 plants had an FL of 100%, suggesting the importance of these species for specific purposes. For instance, *Sceletium tortuosum* [syn. *Mesembryanthemum tortuosum* L.] is preferred for mental health conditions such as stress and anxiety, *Lippia javanica* (Burm.f.) Spreng. is preferred for respiratory conditions such as persistent coughs, colds, Influenza, blocked noses, *Bidens Pilosa* L. is commonly used for toothache and *Eriobotrya japonica* (Thunb.) Lindl. is preferred for conditions such as diabetes and hypertension, just to name a few (Table 2). A fidelity level of 100% can be considered a strong indicator of high consensus for a single specific cultural practice. This could also suggest that the knowledge about this particular use is consistent and reliable in the community. Conversely, Jadid, et al. [58] indicate that a low FL may mean that there is a low abundance of the species in the area or just limited information about the utilization of that plant among local people.

Table 4 Informant consensus factors for medicinal plants use categories reported by participants in Bojanala District

Use category	Number of use reports (Nur)	Number of species (Nt)	Informant consensus factor (ICF)
Respiratory	69	14	0.8
Gynecological and obstetric	11	7	0.4
Musculoskeletal conditions, pain and inflammation	31	20	0.4
Dermatological	24	16	0.3
Reproductive system	14	9	0.4
Gastrointestinal	24	14	0.4
Endocrine systems	4	4	0.0
Kidney and urinary tract	8	5	0.4
Mental health	7	3	0.7
Pediatric	5	3	0.5
Cardiovascular	38	18	0.5
Dental conditions	3	2	0.5
Spirituality	16	4	0.8
Tonic	10	7	0.3
Various disease categories	11	8	0.3

Informant consensus factor (ICF)

Table 4 presents the consensus among participants across different ailment categories in the study area. ICF values in this study ranged from 0.0 to 0.8, with the highest levels of agreement recorded for respiratory conditions and spiritual ailments (0.8 each), followed by mental health (0.7), cardiovascular conditions (0.5), and other disease categories. In contrast, dermatological conditions exhibited the lowest consensus (0.3), indicating greater variability in the selection and application of remedies for these ailments. These patterns suggest that while certain health issues, such as respiratory and spiritual conditions, are associated with well-established culturally entrenched treatments, others, including dermatological concerns, may lack a universally recognized or standardized approach within communities. Notably, plants with high ICF values, such as *Artemisia afra*, *Dicoma anomala*, and *Eucalyptus camaldulensis* Dehnh., are considered culturally significant and widely trusted as effective remedies for respiratory conditions [102–104]. The elevated consensus for these species underscores their potential as candidates for more detailed pharmacological validation and bioprospecting, including the identification of bioactive compounds with therapeutic relevance. This interpretation aligns with observations by Gazzaneo, et al. [105] and Canales, et al. [106], who emphasize that ICF values approaching 1 reflect a high degree of agreement among informants, highlighting both the perceived efficacy of the plant and its cultural prominence. Conversely, lower ICF values may indicate divergent traditional knowledge, variation in local practices, or the absence of a universally acknowledged

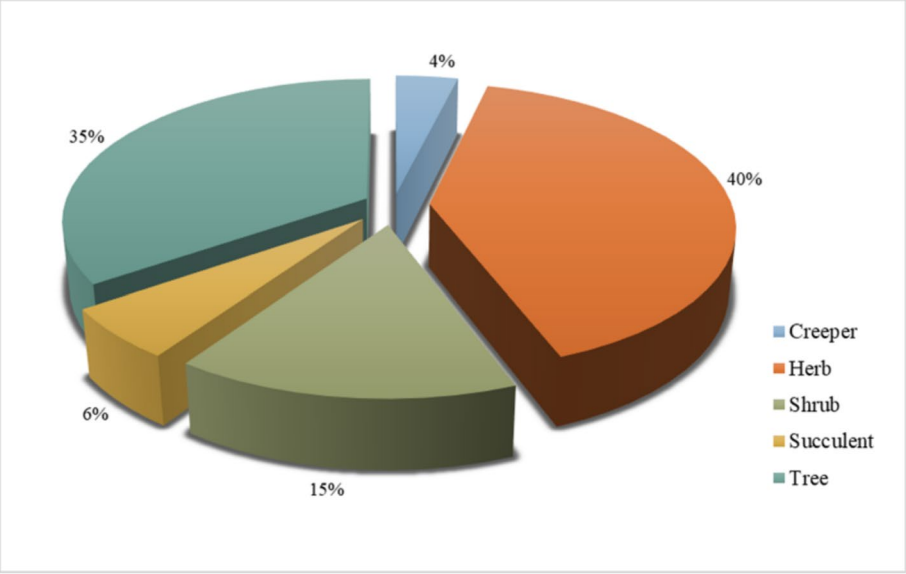

Fig. 3 Distribution of life forms of utilized medicinal plant species in Bojanala District, North-West Province, South Africa (n = 52)

Table 5 Plant part values (PPVs) of parts used in traditional healing in Bojanala District, North-West Province, South Africa

Plant parts	$RU_{plant\ part}$	PPV
Bark	9	0.118
Bulbs, rhizomes, tubers	8	0.105
Flower	5	0.066
Leaves	25	0.329
Roots	18	0.237
Seeds	2	0.026
Stem/branches	1	0.013
Thorns	1	0.013
Whole plant	7	0.092
RU	**76**	

*$RU_{plant\ part}$: plant part reported use, *PPV* Plant part value, *RU* Reported use

treatment, providing important insights into areas where further ethnopharmacological research may be warranted.

Plant forms

Medicinal plants used in the Bojanala District exhibit diverse growth forms (Fig. 3). The majority species were herbs (40%), followed by trees (35%), shrubs (15%), succulents (6%), and creepers (4%). These results are similar to Hu, et al. [81], Mekonnen, et al. [107] and Ndhlovu, et al. [36], who also reported herbs as the predominant growth form of medicinal plants. According to Hu, et al. [81], herbs are more "widely distributed", occurring almost everywhere compared to other habitats like shrubs and trees, and are easier to gather. Ndhlovu, et al. [36] further note that from a conservation standpoint, the use of herbs in herbal medicine is encouraged because they regenerate or grow more quickly after harvest.

Plant parts used

In traditional medicine systems across the world various parts of the plants are utilized for their healing properties. In this study, leaves were found to be the most preferred plant in herbal medicine with a Plant part value (PPV) of 0.329, followed by roots, barks and bulbs, rhizomes and tubers with a PPV of 0.237, 0.118 and 0.105 respectively *(*Table 5*).* The frequent use of leaves over other plant parts in herbal medicine was also observed by several researchers in Africa [24, 107–109]. According to Chaachouay, et al. [108], the choice of leave can be attributed to their easy availability, harvesting process and ease of remedy preparation. Additionally, Ahmed [110] stated that using leaves is preferable to using parts such as roots and bark because it is better for the durability and sustainable development of medicinal plants. This is supported by Maroyi [111], Semenya and Potgieter [23] and Asong, et al. [38], who further mention that the overuse of those plant parts may threaten the existence of certain plant species. Although it is not advisable to use roots and barks excessively, these plant parts are said to contain the most active ingredients and a high concentration of phytochemicals [2, 23].

Method of preparation

There are various methods of preparing herbal remedies, and a specific method is chosen to enhance the remedy's efficacy in treating or preventing a particular condition [2, 112]. Asong, et al. [113] mention that the selection of a method can sometimes be attributed to the complexity or simplicity of the remedy's preparation. Findings of this study showed that decoction (54%), burning (12%), and infusion (11%) were the most common methods of

preparation (Fig. 4). These findings are consistent previous studies [23, 81, 109], which decoction was the most popular preparatory method. Research further reveals that decoction is among the most well-documented methods of preparation in traditional medicine [114], and one of the most important methods in the South African traditional healing system [23]. Interestingly, burning was among the most preferred methods in the Bojanala District. With this method, dried plant parts are burned for their therapeutic smoke or to create char. According to Braithwaite, et al. [115], burning is also a common practice in African traditional healing. Other preparatory methods used traditional healing systems in the study area included crushing & grinding (7%), poultice (6%), chewing (4%) and juicing/blending (3%). Some remedies did not require any intensive methods as participants mentioned that some plant parts are used as they are, fresh from harvest. It was interesting to see poultice among the least used methods of preparation, whereas as previous studies found it among the most commonly used [47, 116].

Route of administration and dosage

The majority of herbal remedies were administered orally, followed by topical application, with steaming and smoke inhalation being less common (Fig. 5), consistent with Semenya, et al. [22]. Oral administration is preferred due to ease of use and efficient absorption [23, 81], often with additives such as sugar or honey to mask bitterness. Topical applications were mainly used for dermatological conditions [109], while steaming and smoke inhalation were applied for respiratory issues, congestion, headaches, and anxiety [2, 115]. The effectiveness of a remedy often depends on its dosage [107]; however, in this study, dosages were not standardized, with participants prescribing different amounts for the same condition. The most common measuring tool was a metal/tin cup *("bekere/lebekere"),* ranging from ¼ to 1 full cup per dose, administered once to three times daily. Dosages varied between adults and children, with children receiving smaller amounts. One traditional health practitioners noted, *"dihlare ga dina bontsi kgotsa bonnyane"*, but the smaller the dosage the better." Participants also recommended adding water to remedies to protect vital organs such as the liver and kidneys, as traditional medicines are potent. Some remedies were used "as needed," reflecting the absence of standardized dosages, which varied between communities and practitioners, and highlighting a key limitation of traditional medicine compared to complementary practices [117, 118]. The preparation methods, routes of administration, and dosages varied widely, including oral intake, topical application, steaming, smoke inhalation, bathing, and enemas. This variability complicates pharmacological validation, limiting

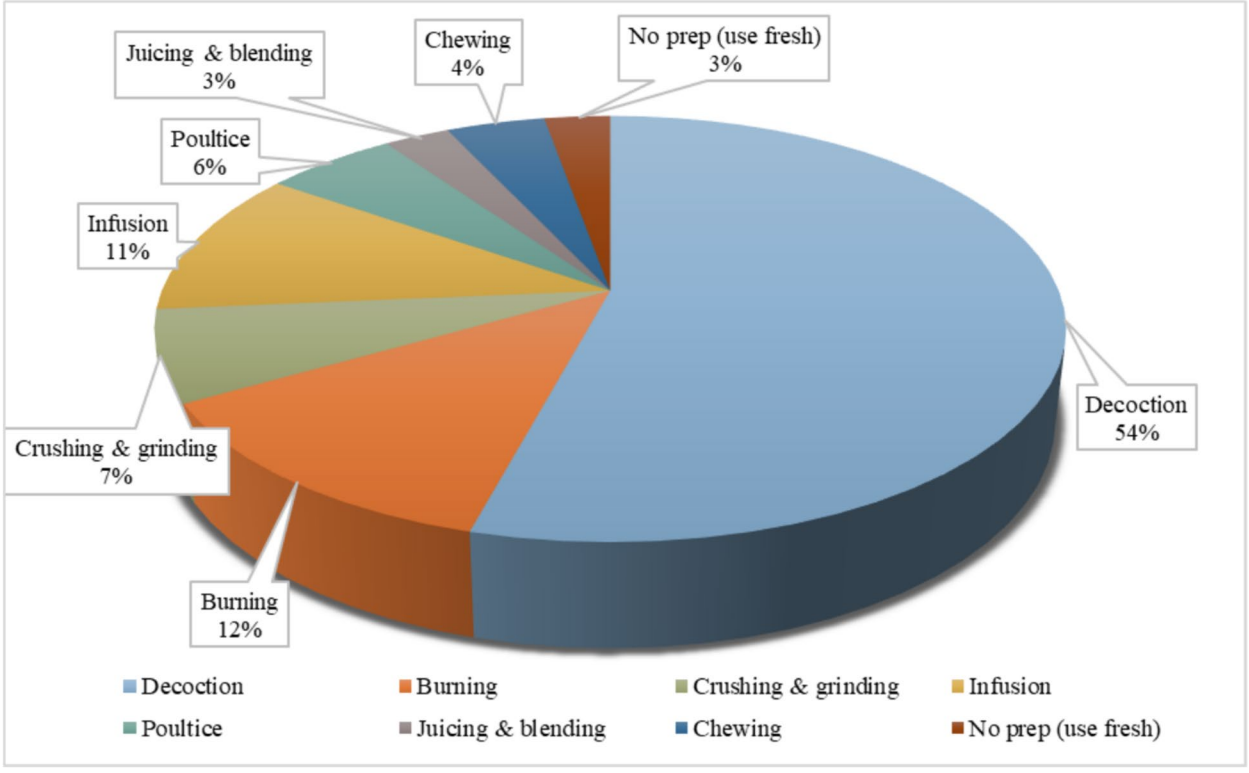

Fig. 4 Method of preparation used in traditional healing systems in Bojanala District, North-West, South Africa (n = 72)

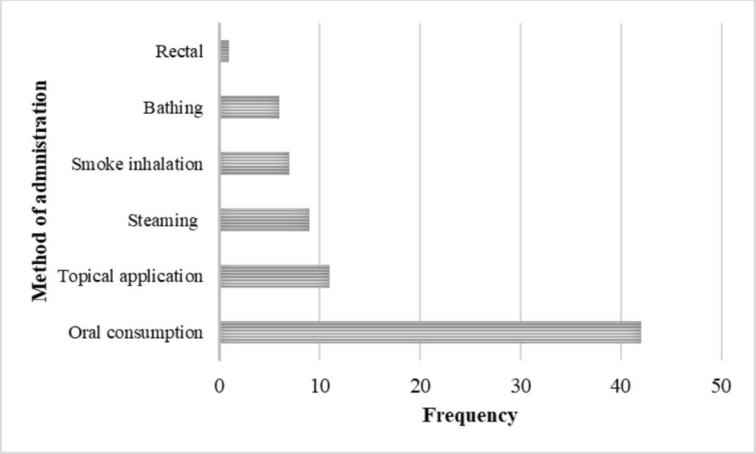

Fig. 5 Route of administration of herbal remedies in traditional healing systems in Bojanala District, North-West Province, South Africa

the determination of effective therapeutic ranges, safety thresholds, and reproducibility, and thereby hindering clinical translation. Thus, future research should focus on dosage standardization, pharmacokinetic evaluation, and safety assessment to improve the clinical relevance and integration of these medicinal plants into evidence-based healthcare [119, 120].

Commonly encountered health conditions in the study areas

The results of this study reveal that community members in the study areas utilize traditional medicine/phytomedicine for various health conditions. The majority of medicinal plants in this study were used for musculoskeletal conditions, pain and inflammation. Musculoskeletal conditions are conditions affecting the locomotor system, characterized by pain and reduced physical function [121]. According to Khumalo, et al. [122], Inflammatory and pain-related conditions continue to be a major global concern affecting all people worldwide. The majority of people globally suffer from chronic pain and this has a negative impact on their lives [123]. Pain makes it difficult for people to carry out their activities; it increases their use of medication and the cost of healthcare [122]. Research shows that in developing countries, back pain and headaches were found to be the most prevalent types of chronic pain [124]. The most commonly utilized medications for these conditions are, however, often associated with adverse and harmful side effects [125] and this could be one of the reasons why people choose to use alternatives such as traditional medicine to relieve their symptoms. In this study, 20 plant species were used to treat musculoskeletal conditions, pain and inflammation.

Cardiovascular conditions are a group of conditions affecting the heart and blood vessels and are among the leading causes of death worldwide. The WHO reports that over 17 million people die from cardiovascular diseases every year, with heart attacks and stroke accounting for four out of five of these deaths. In this study, only two plant species, *Musa acuminata* Colla and *Punica granatum* L., were reported to treat heart conditions and stroke, respectively. Similarly, Edenta, et al. [126] noted that fruit peels of *Musa acuminata* are used treat of hypertension and cardiovascular diseases in northern Nigeria. A study by Yadav [127] investigating the therapeutic value of *Musa acuminata* found that this species has antioxidant, anti-diabetic, hypolipidemic and antimicrobial properties, allowing it to treat and cure a variety of illnesses. In South Africa, hypertensive disease accounts for about 3.7% of deaths [128, 129].

Five (5) plant species, namely *Aloe ferox*, *Drimia sanguinea*, *Eriobotrya japonica, Hypoxis hemerocallidea* Fisch., C.A.Mey. & Avé-Lall., *Moringa oleifera* Lam. and *Psidium guajava* L., were used to manage hypertension in the study area. Blood cleansing also appeared to be very popular in the study area, with twelve (12) species used for this purpose. These include *Drimia sanguinea, Eucomis autumnalis* (Mill.) Chitt., *Hypoxis hemerocallidea,, Moringa oleifera, Monsonia angustifolia* E.Mey., *Peltophorum africanum* Sond., *Schinus polygama* (Cav.) Cabrera, *Sclerocarya birrea* (A. Rich.) Hochst. subsp. *caffra* (Sond.) Kokwaro, *Senna italica* Mill. *subsp. arachoides* (Burch.) Lock, *Vachellia xanthophloea* (Benth) P.J.H. Hurter *and Ziziphus mucronata* Willd. subsp. *mucronata*. Similarly, Mhlongo and Van Wyk [27] and De Wet and Ngubane [130] reported that *Eucomis autumnalis*, *Sclerocarya birrea* and *Peltophorum africanum* were used to purifying blood in the Kwa-Zulu Natal Province. In many African cultural traditions, blood is considered sacred. These traditions believe that sicknesses are not just coincidental occurrences, but also a result of spiritual and social imbalance [131]. Therefore, detoxification or purification is seen as a means to achieve holistic healing.

Dermatological conditions are skin-related conditions. Asong, et al. [38] and Khoza [65] reported that dermatological infections are a significant public health concern in developing countries, accounting for over 30% of all occupational health problems. According Matlala, et al. [112], there is a shortage of dermatologists in South Africa and the cost of medication for dermatological conditions is too high. Fifteen (15) plant species were used for treating dermatological conditions in Bojanala district. The most popular plants used were *Aloe ferox*, *Aloe vera* (L) and *Ziziphus mucronata,* with three reported uses for skin conditions, including rash, abscess, acne, eczema, boils, ulcers and alopecia. In contrast, Asong, et al. [38], identified *Hypoxis hemerocallidea*, *Helichrysum paronychiodes* DC, *Elephantorrhiza elephantina*, and *Senecio longiflorus* as the most commonly used plant species for skin conditions in the North-West Province.

Respiratory conditions are known to affect the airways, from the nasal cavity to the throat to the lungs [132, 133]. Over one billion people across the globe suffer from respiratory tract infections and it is found to be one of the leading causes of death in developing countries [133]. In developing countries such as South Africa, where there are numerous risk factors such as the utilization of biomass fuels, crowded living conditions, smoking and dust, the health impacts of these infections are severe [25]. *Artemisia afra* was the most commonly used plant for respiratory conditions. Liu, et al. [134], Suliman, et al. [135] and Adeleye, et al. [136] also indicted importance of this species in treating respiratory conditions. *Cannabis sativa* L., *Dicoma anomala*, *Eucalyptus camaldulensis* and *Lippia javanica* were also among the very popular plants for respiratory conditions in the study, with 3–4 reported uses each.

Various reproductive system conditions were treated with herbal medicine in the study area. Erectile dysfunction appeared to be the most commonly treated condition with six mentions. *Balanites maughamii*, *Drimia sanguinea*, *Elephantorrhiza elephantina*, *Monsonia angustifolia, Senegalia caffra* (Thunb.) P.J.H. Hurter & Mabb (*Syn: Acacia caffra* (Thunb.) Willd.) and *Hypoxis hemerocallidea* were reportedly used for the treatment of erectile dysfunction. Contrary to this, Semenya and Potgieter [23] found that *Zanthoxylum humile* (E.A.Bruce) P.G.Waterman, *Catha edulis* (Vahl) Endl., *Ozoroa sphaerocarpa* R.Fern. & A.Fern. and *Hypoxis hemerocallidea* to be the most commonly used remedies for erectile dysfunction in Limpopo Province. Vaginal thrush (*Sebabo)* also appears to be a problem in the study area, treated with *Aloe ferox, Drimia sanguinea, Monsonia angustifolia, Sclerocarya birrea* and *Schinus polygama* (Cav.) Cabrera. Other plants were used to treat menstrual cramps, miscarriages and to improve fertility. Khoza [65] mentions that black South Africans place a high value on fertility because it ensures the survival and growth of the tribe, and usually a barren person is seen as a disgrace. Additionally, a study by Mashile, et al. [137] found that individuals who suffer from menstrual cramps or dysmenorrhea have difficulty conceiving because their wombs are "tied".

Gastrointestinal conditions were prevalent in the study area and treated with 14 plant species, primarily for stomachache and diarrhoea. Such conditions are often linked to poor sanitation and limited access to clean water, challenges that are particularly pronounced in South Africa's North-West Province [36, 112]. The species commonly used included *Dicoma anomala, Drimia sanguinea, Dysphania ambrosioides* (L.) Mosyakin & Clemants, *Peltophorum africanum, Prunus persica, Punica granatum, and Schkuhria pinnata* (Lam.) Kuntze ex Thell., with *Dysphania ambrosioides* also employed for piles and constipation. According to de Wet, et al. [28], gastrointestinal conditions are often linked to poor sanitation and insufficient access to clean drinking water. Other studies reported that *Euclea divinorum* Hiern, *Siphonochilus aethiopicus* (Schweinf.) B.L.Burtt, *Sclerocarya birrea* and *Aloe maculata* are among the plants used for gastrointestinal conditions [27, 36, 65].

In this study, four species were used for the management of *diabetes mellitus*: *Aloe ferox, Eriobotrya japonica, Mangifera indica, and Moringa oleifera.* Several studies have also found *Aloe ferox, Hypoxis hemerocallidea* and *Moringa oleifera* to be popular for management of diabetes *mellitus* [22, 32, 65, 138, 139]. *Diabetes mellitus* found to be among the leadings causes of death in South Africa, accounting for 4.8% of the population [128, 129]. While *Eriobotrya japonica* has no reported use for *diabetes mellitus* in South African traditional medicine, it has been employed in Japanese and Chinese traditional medicine for this purpose [140].

Ndhlovu, et al. [36] indicated that although the current mortality rates for newborns align with the United Nations Sustainable Development Goal (SDG-3) target of 12 deaths for every 1000 live births, South Africa still faces an unacceptably high infant mortality rate, with over 20 deaths per 1000 live births. According to Maroyi [141], children are vulnerable to a variety of infections and diseases due to their weakened immune systems. *Hlogwana ya ngwana*, also known as sunken fontanelle disease, was the most commonly treated pediatric condition in the study area, a finding similar to of Maroyi [141] and Towns, et al. [142]. This condition is known to contribute to the morbidity and mortality of children under the age of 5 [36] and it is often associated with symptoms such as weight loss, persistent vomiting, loss of appetite and sunken eyes [65]. Furthermore, Khoza [65] and Ndhlovu, et al. [36] mentioned that this condition is believed to be caused by bad spirits and should be

treated immediately. *Asparagus suaveolens* Burch*, Dysphania ambrosioides and Siphonochilus aethiopicus* were reported to be used for pediatric conditions in the study area.

Knowledge and practices associated with phytomedicinal utilization in Bojanala District

Indigenous people in the study area have relied on traditional medicine for generations. In addition to information about which medicinal plants are used for what health conditions, the researcher had a lot to learn. In this study, some traditional health practitioners mentioned that there is a specific time to collect medicinal plants. For instance, you do not collect plants at midday (around 12h00) and in the evenings after the sun sets. Medicinal plants should be collected very early in the morning. No explanation was given to the researcher as to why it was like that. Furthermore, one participant indicated that certain plant or animal materials are picked and used in traditional medicine because of their alleged symbolic meanings. For example, certain plants may be associated with a particular condition, protection or strength. It was also mentioned that when treating children, one has to use small or new plants and that when harvesting a plant part, you have to pay attention to the direction of the sun in which it is hitting the plant. All of these practices in traditional healing systems reflect the cultural beliefs of indigenous communities.

Conservation status of registered plants

Concerning conservation status, plant species used as traditional medicine in the Bojanala District were classified according to the South African National Biodiversity Institute (SANBI) Red List for South African Plants (http://redlist.sanbi.org/) as Least Concern (LC), Not Evaluated, Near Threatened (NT), Critically Endangered (CR), and Data Deficient (DD) *(*Table 2*)*. The results indicate that the majority (61%) of medicinal plant species recorded in this study are currently classified as Least Concern (LC). Although the majority of medicinal plant species recorded in this study (61%) are classified as LC and are not considered formally threatened, this status may obscure emerging pressures. For example, *Hypoxis hemerocallidea* has been extensively exploited commercial use since the late 1960 s [143], *Balanites maughamii* Sprague is adversely affected by habitat degradation and overharvesting for medicinal purposes [144]. While SANBI assessments classify these species as LC, local observations suggest that population declines are occurring. Participants from Legonyane village in the North-West Province reported reductions in *Dicoma anomala* and *Drimia sanguinea* due to intensive harvesting by external practitioners. These findings highlight the discrepancy between LC classification and on-the-ground pressures, emphasizing the need to integrate community-based knowledge with formal conservation assessments to guide proactive management and ensure sustainable use of medicinal plant resources.

Overall, 31% of the recorded species were classified as Not Evaluated or not listed, 4% as Near Threatened, 2% as Critically Endangered, and 2% as Data Deficient (Fig. 6). According to SANBI, species classified as Not Evaluated are often naturalized exotics that are not indigenous to South Africa but have successfully established and reproduced in the wild [145–147].

These findings align with broader evidence showing that medicinal plants globally, including those in South Africa, are experiencing population declines driven by overharvesting, unsustainable trade, habitat loss, climate change, and other anthropogenic pressures [17, 148]. Notably, *Siphonochilus aethiopicus* is classified by SANBI as Critically Endangered under IUCN criteria, owing to severe population reductions, extensive range contraction, and sustained exploitation for the traditional medicine trade. SANBI reports that the species is extinct across much of its former range, with remaining wild populations occurring at critically low levels [149].

The conservation of medicinal plants is therefore imperative, given their documented cultural, livelihood, and economic importance in South African communities. Previous studies emphasize that effective conservation strategies should be grounded in robust population assessments and aligned with Red List criteria [150, 151]. Recommended interventions include integrated in situ and ex situ conservation approaches, improved regulation and documentation of medicinal plant trade, promotion of sustainable harvesting practices, domestication of high-demand species, incorporation of community and gender perspectives into conservation planning, and the protection of traditional knowledge and intellectual property rights [152, 153].

Limitations of the study

Bojanala District has a total of five (5) local municipalities, and it would have been better if the researcher collected data in all five local municipalities to give a clear representation of phytomedicinal utilization within the district. However, due to financial constraints, the researcher could only collect data in one local municipality, Madibeng. Participants were chosen to represent different age groups, genders, education levels, and occupations, thereby minimizing bias towards any single subgroup. However, that is still not enough to be considered a proper representation of the general population in the district. Additionally, the study focused on the views of only indigenous knowledge holders and traditional health practitioners on the use of phytomedicine. A larger sample size could have given a better insight into the study,

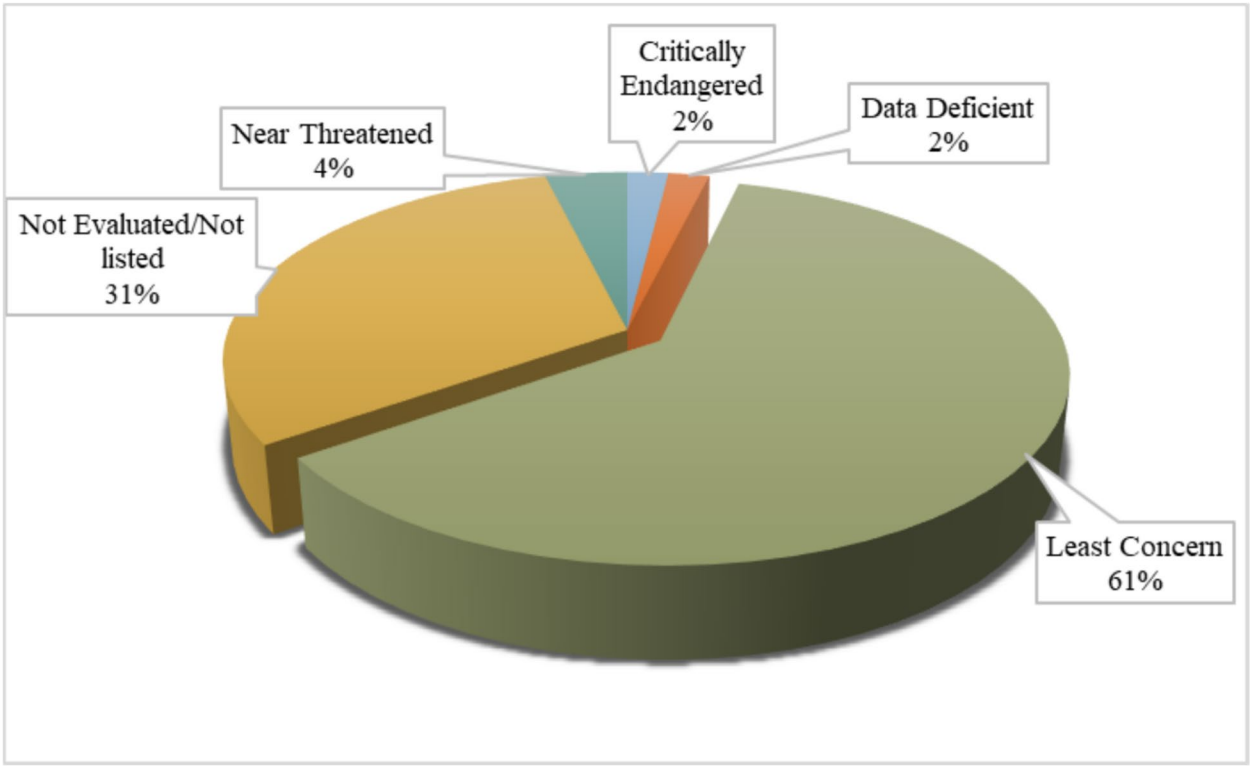

Fig. 6 Conservation status of medicinal plants used in Bojanala District, North-West Province, South Africa

but only 37 participants were identified. Many knowledge holders were uncomfortable sharing their knowledge due to privacy concerns and fear of misuse of their information by the researcher, while others wanted to be paid for their time. This prevented the researcher from accessing valuable information that knowledge holders could have provided.

Conclusion

The findings of this study and the summary provided shed more light on the cultural heritage of people in the Bojanala District and highlight the variety of medicinal plant use within the study area, adding to the knowledge of South African and African literature on the documentation of medicinal plants by indigenous people. Ethnobotanical research, such as this study, plays an essential role in documenting and preserving traditional knowledge systems developed and passed down through generations. By systematically recording the uses of medicinal plants and associated knowledge and practices, this study aims to protect invaluable indigenous knowledge that is at risk of being lost due to cultural changes, urbanisation, and the deterioration of oral traditions as Western lifestyles are embraced. This knowledge, which ought to be protected, serves as a foundation for pharmacological discoveries, as many modern drugs considered basic and essential are derived from traditional medicine. For example, well-known medications, such as aspirin, morphine and quinine, have emerged from ethnobotanical leads. It is because of ethnobotanical research, such as this study, that one can harness the therapeutic potential of important plant species, whose chemical compounds form the basis of powerful drugs used to treat or prevent various health conditions. Furthermore, this study also has significant implications for biodiversity conservation. This study revealed that the growing commercial demand for certain medicinal plants has led to overharvesting and population declines of some important species. Thus, by identifying species that are highly exploited, this study can provide important information for prioritising conservation and implementing sustainable harvesting practices. Therefore, this study recommends practical harvesting guidelines aligned with SANBI guidelines and South Africa's National Environmental Management Biodiversity Act of 2004, which advocate for the protection of biodiversity. These recommendations include harvesting renewable plant parts such as leaves, fruits and flowers, avoiding destructive practices like complete uprooting and ringbarking and implementing rotational harvesting to allow medicinal plant populations to recover. Additionally, there should be protection measures for high-demand, slow growing medicinal plant species, including limits on harvesting and regulations enforced by the community or province. For instance, no individual should harvest protected species from the wild without a permit from the relevant authority. This study

also recommends the cultivating commonly used medicinal plant species in home gardens to reduce pressure on wild populations. Most importantly, communities should collaborate with provincial conservation authorities to promote inclusivity and ensure long-term sustainability.

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions
Matlala Maropeng Erica: Conceptualisation, Methodology, Formal analysis, Investigation, Resources, Writing – original draft preparation. Chauke Sinorita: review and editing, proofreading. Ramarumo Luambo Jeffrey: Conceptualisation, Methodology, Writing – review and editing, Supervision. Ramarumo Luambo Jeffrey and Kola Elizabeth: Conceptualisation, Formal analysis, Writing – review and editing, Supervision. Peter Tshepiso Ndhlovu: Conceptualisation, Methodology, Formal analysis, Investigation, Writing – review and editing, Supervision, Project administration, Funding acquisition.

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Data availability
The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author/s.

Declarations

Ethics approval and consent to participate
This study was carried out in full compliance with the ethical principles of the Declaration of Helsinki. Ethical clearance was obtained from the University of Mpumalanga (Reference Number: (*UMP/Matlala 220207089/SBES/MSc/2024/1*). Additionally, authors obtained approval to collect data among traditional health practitioners and community members from the Traditional Health Practitioners Organization (THO) and Bakwena ba Mogopa Tribal Authority. Informed consent was obtained from all the participants involved in the study. The North-West Department of Economic Development, Environment, Conservation and Tourism permitted the collection of plants in the study area. In line with ethnobiological ethics and the Nagoya Protocol principles, the findings and outcomes of this study will be shared with the participating communities to ensure benefit-sharing and provide feedback on the documented plant knowledge.

Consent for publication
Not applicable.

Competing interests
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References

2. Ozioma Ezekwesili-Ofili JO, Okaka A. Herbal Medicines in African Traditional Medicine. In Herbal Medicine, Edited by Builders PF. London, United Kingdom font-family:"Aptos",sans-serif;mso-ascii-font-family:Aptos;mso-ascii-theme-font:minor-latin;mso-fareast-font-family:Aptos;mso-fareast-theme-font:minor-latin;mso-hansi-font-family:Aptos;mso-hansi-theme-font:minor-latin;mso-bidi-font-family:"Times New Roman".
3. Sebata TP. The role of traditional healers in the treatment of HIV and AIDS in Tsetse Village: The case of Mahikeng in the North West Province. Master dissertation ,North-West University, Mmabatho, 2015.
4. Mokgobi MG. Views on traditional healing: Implications for integration of traditional healing and Western medicine in South Africa. Doctoral dissertation, University of South Africa, Pretoria, 2012.
5. Mmamosheledi EM. Mncengeli, S. African Traditional Medicine: South African Perspective. In Traditional and Complementary Medicine, Cengiz, M. Ed; IntechOpen: London, United Kingdon, 2019.
6. Payyappallimana U. Role of traditional medicine in primary health care: an overview of perspectives and challenging. Yokohama J Soc Sci. 2010;14:57–77.
7. Ross AI. The anthropology of alternative medicine. New York: Routledge; 2020.
8. Hussain, S.; Malik, F.; Khalid, N.; Qayyum, M.A.; Riaz, H. Alternative and traditional medicines systems in Pakistan: history, regulation, trends, usefulness, challenges, prospects and limitations. A compendium of essays on alternative therapy 2012, 67.
9. Patwardhan B, Partwardhan A. Traditional Medicine: Modern Approach for affordable global health. Geneva: World Health Organization Switzerland; 2005.
10. Malerba L. Green Medicine: Challenging the assumptions of conventional health care; North Atlantic Books, California United States of America: 2010.
11. Nair BR, Perera K, Sreeshma L. Modern ethnobotany and the development of drug leads. In Conservation and Sustainable Utilization of Bioresources: Springer; 2023. p. 505–29.
12. Veliz MVP. Plants as Relatives: Silphium Ethnobotany. Decolonization and Traditional Knowledge: University of Kansas; 2024.
13. Ndou RV. A study of ethnoveterinary medicine in the North West Province. South Africa: North-West University (South Africa); 2018.
14. Kindie B, Mengistu S. Ethnobotanical study of medicinal plant and traditional knowledge used. J Tradit Med Clin Naturopathy. 2022;11:10.4172.
15. Regassa R. Assessment of indigenous knowledge of medicinal plant practice and mode of service delivery in Hawassa city, southern Ethiopia. J Med Plants Res. 2013;7:517–35.
16. Mahmood A, Mahmood A, Malik RN, Shinwari ZK. Indigenous knowledge of medicinal plants from Gujranwala district, Pakistan. J Ethnopharmacol. 2013;148:714–23.
17. Matlala ME, Ndhlovu PT, Mokgehle SN, Otang-Mbeng W. Ethnobotanical investigation of *Mimusops zeyheri*, an underutilized indigenous fruit tree in Gauteng Province, South Africa. Sustainability. 2024. https://doi.org/10.3390/su16041410.
18. Tshidzumba PW. An inventory and pharmacological evaluation of medicinal plants used as anti-diabetes and anti-arthritis in Vhembe District Municipality, Limpopo Province. Masters Thesis, University of Venda, Thohoyandou, 2018.
19. Marie H. Emerging trends in the generation, transmission and protection of traditional knowledge. Indigenous Policy J. 2019;30:1–15.
20. Falemara BC, Joshua VI, Ogunkanmi TI, Mbeng WO. Ethnomedicinal survey of indigenous medicinal plants in Jos Metropolis, Nigeria. J Med Plants Econ Dev. 2021;5:128.
21. Twilley D, Rademan S, Lall N. A review on traditionally used South African medicinal plants, their secondary metabolites and their potential development into anticancer agents. J Ethnopharmacol. 2020;261:113101.
22. Semenya S, Potgieter M, Erasmus L. Ethnobotanical survey of medicinal plants used by Bapedi healers to treat diabetes mellitus in the Limpopo Province, South Africa. J Ethnopharmacol. 2012;141:440–5.
23. Semenya SS, Potgieter MJ. Ethnobotanical survey of medicinal plants used by Bapedi traditional healers to treat erectile dysfunction in the Limpopo Province, South Africa. J Med Plants Res. 2013;7:349–57.
24. Ndhlovu P, Mooki O, Mbeng WO, Aremu A. Plant species used for cosmetic and cosmeceutical purposes by the Vhavenda women in Vhembe District Municipality, Limpopo, South Africa. S Afr J Bot. 2019;122:422–31.
25. Semenya SS, Maroyi A. Respiratory infections treated by Bapedi traditional healers in the Limpopo Province, South Africa: Extent of treatments and diagnosis techniques. Indian Journal of Traditional Knowledge, 2018;17(4).

26. Mudau G, Odeyemi S, Dewar J. Vhavenda herbal remedies as sources of antihypertensive drugs: ethnobotanical and ethnopharmacological studies. Oxid Med Cell Longev. 2020;2020:6636766.
27. Mhlongo L, Van Wyk B-E. Zulu medicinal ethnobotany: new records from the Amandawe area of KwaZulu-Natal, South Africa. S Afr J Bot. 2019;122:266–90.
28. de Wet H, Nkwanyana MN, van Vuuren SF. Medicinal plants used for the treatment of diarrhoea in northern Maputaland, KwaZulu-Natal Province, South Africa. J Ethnopharmacol. 2010;130:284–9.
29. De Wet H, Nzama V, Van Vuuren S. Medicinal plants used for the treatment of sexually transmitted infections by lay people in northern Maputaland, KwaZulu–Natal Province, South Africa. S Afr J Bot. 2012;78:12–20.
30. Mbanjwa SG. A quantitative ethnobotanical survey of the Ixopo area of KwaZulu-Natal. South Africa: University of Johannesburg (South Africa); 2020.
31. Gebashe F, Moyo M, Aremu A, Finnie J, Van Staden J. Ethnobotanical survey and antibacterial screening of medicinal grasses in KwaZulu-Natal Province, South Africa. S Afr J Bot. 2019;122:467–74.
32. Odeyemi S, Bradley G. Medicinal plants used for the traditional management of diabetes in the Eastern Cape, South Africa: pharmacology and toxicology. Molecules. 2018;23:2759.
33. Sagbo IJ, Otang-Mbeng W. Plants used for the traditional management of cancer in the Eastern Cape Province of South Africa: a review of ethnobotanical surveys, ethnopharmacological studies and active phytochemicals. Molecules. 2021;26:4639.
34. Thinyane Z, Maroyi A. Medicinal plants used by the inhabitants of Alfred Nzo District Municipality in the Eastern Cape Province, South Africa. J Pharm Nutr Sci. 2019;9:157–66.
35. Moroole MA. An exploration of indigenous contraception among the batswana of ngaka modiri molema district municipality, North West Province, South Africa. Doctoral Dissertation, North-West University (South Africa), Mmabatho, 2021.
36. Ndhlovu PT, Asong JA, Omotayo AO, Otang-Mbeng W, Aremu AO. Ethnobotanical survey of medicinal plants used by indigenous knowledge holders to manage healthcare needs in children. PLoS ONE. 2023;18:e0282113. https://doi.org/10.1371/journal.pone.0282113.
37. Magodielo M. An ethnobotanical study of African traditional medicinal plants in the heritage park of the north west province. Masters thesis, North-West University (South Africa) , Mmabatho, 2018.
38. Asong J, Ndhlovu P, Khosana N, Aremu A, Otang-Mbeng W. Medicinal plants used for skin-related diseases among the Batswanas in Ngaka Modiri Molema District Municipality, South Africa. S Afr J Bot. 2019;126:11–20.
39. Department of Cooperative Governance and Traditional Affairs. Bojanala Platinum District Profile. Rustenburg, 2023.
40. Mokoena O, Ntuli T, Ramarumo T, Seeletse S. Exploring the challenges faced by the small-scale dairy farmers in Bojanala Platinum District Municipality in North-West Province, South Africa. S Afr J Agric Ext. 2023;51:186–209.
41. Gwedla N, Cornelius SFA, Du Toit MJ, Cilliers SS. Stakeholder perceptions of the ecosystem services of health clinic gardens in settlements and small-to medium-sized cities in the North-West Province, South Africa. Land Basel. 2022;11:1904.
42. North West Provincial Government. Socio-Economic Revie and Outlook (SERO). 2024.
43. Willie MM, Maqbool M. Access to public health services in South Africa's rural Eastern Cape Province. Applied Sciences Research Periodicals. 2023;1:35–54.
44. Mpolokeng TG, Mokgau K, Nko KI, Asong JA, Struwig M, Aremu AO. Ethnobotanical uses of traditional African vegetables among three selected villages of Madibeng Local Municipality, South Africa. Genet Resour Crop Evol. 2025. https://doi.org/10.1007/s10722-025-02331-0.
45. Lopez, V.; Whitehead, D. Sampling data and data collection in qualitative research. In Nursing & Midwifery Research: Methods and Appraisal for Evidence-based Practice; Elsevier: 2013; pp. 123–140.
46. Palinkas LA, Horwitz SM, Green CA, Wisdom JP, Duan N, Hoagwood K. Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. Adm Policy Ment Health. 2015;42:533–44.
47. Ndhlovu PT. Socio-economic impact of herbal cosmetics used by women in Vhembe District Municipality. South Africa: North-West University (South Africa); 2019.
48. Tongco MDC. Purposive sampling as a tool for informant selection. Ethnobot Res Appl. 2007. https://doi.org/10.17348/era.5.0.147-158.
49. Constitution of the Replublic of South Africa. Children's Act 38 of 2005. 2005.
50. Sadler GR, Lee HC, Lim RSH, Fullerton J. Recruitment of hard-to-reach population subgroups via adaptations of the snowball sampling strategy. Nurs Health Sci. 2010;12:369–74.
51. Rosenthal G. Interpretive social research: An introduction. Universitätsverlag Göttingen; 2018.
52. Saunders B, Sim J, Kingstone T, Baker S, Waterfield J, Bartlam B, et al. Saturation in qualitative research: exploring its conceptualization and operationalization. Qual Quant. 2018;52:1893–907.
53. Keshoofy A, Lisnyj K, Pearl DL, Thaivalappil A, Papadopoulos A. A qualitative study of university students' perspectives of hope during the COVID-19 pandemic. SAGE Open Med. 2023;11:20503121231185014.
54. Latif, S.S. Integration of African traditional health practitioners and medicine into the health care management system in the province of Limpopo. Ph.D. Thesis University of Stellenbosch, Stellenbosch, South Africa., 2010.
55. Semenya SS, Maroyi A. Plants used by Bapedi traditional healers to treat asthma and related symptoms in Limpopo province, South Africa. Evid Based Complement Alternat Med. 2018;2018:2183705.
56. Chekole G. Ethnobotanical study of medicinal plants used against human ailments in Gubalafto District, Northern Ethiopia. J Ethnobiol Ethnomed. 2017;13:55.
57. El Hachlafi N, Chebat A, Bencheikh RS, Fikri-Benbrahim K. Ethnopharmacological study of medicinal plants used for chronic diseases treatment in Rabat-Sale-Kenitra region (Morocco). Ethnobot Res Appl. 2020;20:1–23.
58. Jadid, N.; Kurniawan, E.; Himayani, C.E.S.; Andriyani; Prasetyowati, I.; Purwani, K.I.; Muslihatin, W.; Hidayati, D.; Tjahjaningrum, I.T.D. An ethnobotanical study of medicinal plants used by the Tengger tribe in Ngadisari village, Indonesia. PlosOne 2020, 15, e0235886.
59. Khan I, AbdElsalam NM, Fouad H, Tariq A, Ullah R, Adnan M. Application of ethnobotanical indices on the use of traditional medicines against common diseases. Evid Based Complement Alternat Med. 2014;2014:635371.
60. Zent, S. Behavioral Orientations towards Ethnobotanical Quantification. In Selected guidelines for ethnobotanical research: a field manual, Alexiades, M.N., Sheldon, J.W., Eds.; New York Botanical Garden Press: New York, 1996.
61. Kayani S, Ahmad M, Zafar M, Sultana S, Khan MPZ, Ashraf MA, et al. Ethnobotanical uses of medicinal plants for respiratory disorders among the inhabitants of Gallies–Abbottabad, Northern Pakistan. J Ethnopharmacol. 2014;156:47–60.
62. Amjad MS, Arshad M. Ethnobotanical inventory and medicinal uses of some important woody plant species of Kotli, Azad Kashmir, Pakistan. Asian Pac J Trop Biomed. 2014;4:952–8.
63. Khanum H, Ishtiaq M, Bhatti KH, Hussain I, Azeem M, Maqbool M, et al. Ethnobotanical and conservation studies of tree flora of Shiwalik mountainous range of District Bhimber Azad Jammu and Kashmir, Pakistan. PLoS ONE. 2022;17:e0262338.
64. Tumoro G, Maryo M. Determination of informant consensus factor and fidelity level of ethnomedicinal plants used in Misha Woreda, Hadiya Zone, Southern Ethiopia. Int J Biodivers Conserv. 2016;8:351–64.
65. Khoza N. An Ethnobotanical study of indigenous knowledge of the medicinal plants used by traditional healers in the rural communities of Nkomazi Local Municipality. Mpumalanga province: University of the Witwatersrand Johannesburg; 2023.
66. Gomez-Beloz A. Plant use knowledge of the Winikina Warao: the case for questionnaires in ethnobotany. Econ Bot. 2002;56:231–41.
67. AB, O.; Daud S.A; Okojie L; Omotayo A.O. Rural infrastructure and production efficiency of food crop farmers: Implication for rural development in Nigeria. 2022.
68. Ramarumo LJ. Ethnobotanical survey of problem weeds, alien invasive plant species and their roles in Nzhelele, Makhado Local Municipality, Limpopo Province. Limpopo, South Africa: South Africa. University of Venda; 2017.
69. Howard, P. The major importance of'minor'resources: Women and plant biodiversity; 1357–9258; JSTOR: Russell Press, Nottingham,UK, 2003.
70. Kainer, K.A.; Duryea, M.L. Tapping women's knowledge: plant resource use in extractive reserves, Acre, Brazil. Economic Botany 1992, 408–425.
71. Senouci, F.; Ababou, A.; Chouieb, M. Ethnobotanical survey of the medicinal plants used in the Southern Mediterranean. Case study: the region of Bissa (Northeastern Dahra Mountains, Algeria). Pharmacognosy Journal 2019, 11.
72. Upadhyay B, Roy S, Kumar A. Traditional uses of medicinal plants among the rural communities of Churu district in the Thar Desert, India. J Ethnopharmacol. 2007;113:387–99.
73. Yiblet Y, Adamu E. An ethnobotanical study of wild edible plants in Tach Gayint district, South Gondar zone, Amhara region, Northwestern Ethiopia. Evid Based Complement Alternat Med. 2023;2023:7837615.
74. Jan HA, Jana S, Walia S, Ahmad L, Sisto F, Bussmannd R, et al. Ethnomedicinal study of medicinal plants used to cure dental diseases by the indigenous population of district Buner, Pakistan. Indian J Tradit Knowl. 2021;20:378–89.

75. Fatima-Zahra E, Fouzia RF, Abdelilah R. Ethnobotanical study of medicinal plants used in traditional medicine in the province of Sidi Kacem, Morocco. Asian J Pharm Clin Res. 2017;10:121–30.
76. Tadesse D, Masresha G, Lulekal E. Ethnobotanical study of medicinal plants used to treat human ailments in Quara district, Northwestern Ethiopia. J Ethnobiol Ethnomed. 2024;20:75.
77. Yimam M, Yimer SM, Beressa TB. Ethnobotanical study of medicinal plants used in Artuma Fursi district, Amhara Regional State, Ethiopia. Trop Med Health. 2022;50:85.
78. Hailemariam, M.B.; Woldu, Z.; Asfaw, Z.; Lulekal, E. Ethnobotany of an indigenous tree Piliostigma thonningii (Schumach.) Milne-Redh.(Fabaceae) in the arid and semi-arid areas of South Omo Zone, southern Ethiopia. Journal of Ethnobiology and Ethnomedicine 2021, 17, 1–18.
79. Seerangan C, Ravi R. A study on inter-generational knowledge transfer and its impact on sustainable well-being. Stud Indian Sociol. 2024;1:23–36.
80. Kilemba, L.; Mafongoya, P. The challenges of documentation and conservation of indigenous knowledge for natural resources management. Indigenous knowledge systems and climate change management in Africa 2017, 139.
81. Hu R, Lin C, Xu W, Liu Y, Long C. Ethnobotanical study on medicinal plants used by Mulam people in Guangxi, China. J Ethnobiol Ethnomed. 2020;16:1–50.
82. Xin B, Mu S, Tan T, Yeung A, Gu D, Feng Q. Belief in and use of traditional Chinese medicine in Shanghai older adults: a cross-sectional study. BMC Complement Med Ther. 2020;20:1–10.
83. Mander, M.; Ntuli, L.; Diederichs, N.; Mavundla, K. Economics of the traditional medicine trade in South Africa care delivery. South African Health Review 2007, 189–196.
84. Hughes GD, Aboyade OM, Clark BL, Puoane TR. The prevalence of traditional herbal medicine use among hypertensives living in South African communities. BMC Complement Altern Med. 2013;13:1–8.
85. Otang-Mbeng W, Grierson DS, Afolayan AJ. A survey of plants responsible for causing irritant contact dermatitis in the Amathole district, Eastern Cape,South Africa. J Ethnopharmacol. 2014;157:274–84.
86. Mogale MMP, Raimondo D, VanWyk B-E. The ethnobotany of Central Sekhukhuneland, South Africa. S Afr J Bot. 2019;122:90–119.
87. Mudau T, Olowoyo J, Amoo S. Ethnobotanical assessment of medicinal plants used traditionally for treating diabetes in Vhembe district, Limpopo Province, South Africa. S Afr J Bot. 2022;146:304–24.
88. Ndhlovu PT, Omotayo AO, Otang-Mbeng W, Aremu AO. Ethnobotanical review of plants used for the management and treatment of childhood diseases and well-being in South Africa. S Afr J Bot. 2021;137:197–215.
89. Cornelius SF, Van Wyk BE. An updated inventory of medicinal and ritual plants of southern Africa. J Ethnopharmacol. 2024;332:118361. https://doi.org/10.1016/j.jep.2024.118361.
90. Rolnik A, Olas B. The plants of the Asteraceae family as agents in the protection of human health. Int J Mol Sci. 2021;22:3009.
91. Bonokwane, M.B.; Aremu, O.; Lekhooa, M.; Struwig, M. Evaluation of indigenous medicinal plants with potential antidepressant effects. 2023.
92. Awoke A, Tahir M. Traditional uses of family Asteraceae in Ethiopia: a review of ethnobotanical knowledge and therapeutic applications. Ethnobot Res Appl. 2025;31:1–25.
93. Mothogoane, M.S. Studies on the medicinally important Rhynchosia (Phaseoleae, Fabaceae) species: taxonomy, ethnobotany, phytochemistry and antimicrobial activity; University of Johannesburg (South Africa): 2019.
94. Tibini, S. Taxonomic studies and systematics of the Subtribe Phaseolinae (Phaseoleae, Fabaceae) in southern Africa; University of Johannesburg (South Africa): 2021.
95. Maroyi A. Medicinal uses of the Fabaceae family in Zimbabwe: a review. Plants Basel. 2023;12:1255.
96. DILLA, E. Woody plant species composition, diversity and structure of woody plants in Gawus Natural Forest, South Bench District, BENCH SHEKO ZONE, SOUTH WEST ETHIOPIA. 2021.
97. Masresha G, Melkamu Y, Walle GC. Ethnobotanical study on wild edible plants in Metema District, Amhara Regional State, Ethiopia. Int J For Res. 2023;2023:9243343.
98. Salehi B, Gültekin-Özgüven M, Kırkın C, Özçelik B, Morais-Braga FBM, Carneiro NPJ, et al. *Anacardium* plants: chemical, nutritional composition and biotechnological applications. Biomolecules. 2019;9:465.
99. Guerra RNM, Oliveira AS, Farias JR, Franco DCG, Santos PG, Barbosa NT, et al. Anacardiaceae family: effect of isolated compounds and other identified phytochemicals against clinically relevant *Candida* species—a short review. Antibiotics Basel. 2025;14:308.
100. Odukoya JO, Odukoya JO, Mmutlane EM, Ndinteh DT. Ethnopharmacological study of medicinal plants used for the treatment of cardiovascular diseases and their associated risk factors in sub-Saharan Africa. Plants Basel. 2022;11:1387.
101. Afolayan AJ, Grierson DS, Mbeng WO. Ethnobotanical survey of medicinal plants used in the management of skin disorders among the Xhosa communities of the Amathole District, Eastern Cape, South Africa. J Ethnopharmacol. 2014;153:220–32.
102. Trotter, R.T.; Logan, M.H. Informant consensus: A new approach for identifying potentially effective medicinal plants. In Plants and Indigenous Medicine and Diet; Routledge: London, UK, 2019; pp. 91–112.
103. Uddin MZ, Hassan MA. Determination of informant consensus factor of ethnomedicinal plants used in Kalenga Forest, Bangladesh. Bangladesh J Plant Taxon. 2014;21:83–91.
104. Hassan N, Wang D, Zhong Z, Nisar M, Zhu Y. Determination and analysis of informant consensus factor of medicinal plant species used as remedy in Northern Pakistan. J Biodivers Environ Sci. 2017;11:117–33.
105. Gazzaneo LRS, De Lucena RFP, de Albuquerque UP. Knowledge and use of medicinal plants by local specialists in an region of Atlantic Forest in the state of Pernambuco (Northeastern Brazil). J Ethnobiol Ethnomed. 2005;1:9.
106. Canales M, Hernández T, Caballero J, De Vivar AR, Avila G, Duran A, et al. Informant consensus factor and antibacterial activity of the medicinal plants used by the people of San Rafael Coxcatlán, Puebla, México. J Ethnopharmacol. 2005;97:429–39.
107. Mekonnen AB, Mohammed AS, Tefera AK. Ethnobotanical study of traditional medicinal plants used to treat human and animal diseases in Sedie Muja District, South Gondar, Ethiopia. Evid Based Complement Alternat Med. 2022;2022:7328613.
108. Chaachouay N, Benkhnigue O, Zidane L. Ethnobotanical study aimed at investigating the use of medicinal plants to treat nervous system diseases in the Rif of Morocco. J Chiropr Med. 2020;19:70–81.
109. Oyeniyi, O.; Aghedo, O.G.; Akwolu, C.C.; Uwaoma, C.P.K. Ethnobotanical Survey of Medicinal Plants Used in the Treatment of Skin Infections in Ogun and Oyo States, Nigeria. Journal of Public Health 2025, 2.
110. Ahmed HM. Ethnopharmacobotanical study on the medicinal plants used by herbalists in Sulaymaniyah Province, Kurdistan, Iraq. J Ethnobiol Ethnomed. 2016;12:1–17.
111. Maroyi A. An ethnobotanical survey of medicinal plants used by the people in Nhema communal area, Zimbabwe. J Ethnopharmacol. 2011;136:347–54.
112. Matlala ME, Lubisi NP, Chauke S, Kola E, Ramarumo LJ, Ndhlovu PT. Plant species used to treat various ailments of the North-West Province, South Africa: a systematic review. Next Research. 2025. https://doi.org/10.1016/j.nexres.2025.100446.
113. Asong, J.; Ndhlovu, P.; Olatunde, A.; Aremu, A. Uses of African Plants and Associated Indigenous Knowledge for the Management of Diabetes Mellitus. Diabetology 2024, 5, 476–490. Diabetology 2024, 5, 476–490.
114. Tandon S, Rane S. Decoction and hot continuous extraction techniques. Extraction technologies for medicinal and aromatic plants. 2008;93:12–8.
115. Braithwaite M, Van vuuren S, Viljoen A. Validation of smoke inhalation therapy to treat microbial infections. J Ethnopharmacol. 2008;119:501–6. https://doi.org/10.1016/j.jep.2008.07.050.
116. Cussy-Poma V, Fernández E, Rondevaldova J, Foffová H, Russo D. Ethnobotanical inventory of medicinal plants used in the Qampaya District, Bolivia. Bol Latinoam Caribe Plantas Med Aromat. 2017;16:68–77.
117. Hamanyanga, N. Perspectives of health workers on traditional medicine Integration into conventional medicine in selected Health facilities in Zimba district. Doctoral dissertation, University of Zambia, 2019.
118. Saggar S, Mir PA, Kumar N, Chawla A, Uppal J, Kaur A. Traditional and herbal medicines: opportunities and challenges. Pharmacogn Res. 2022. https://doi.org/10.5530/pres.14.2.15.
119. Heinrich M, Edwards S, Moerman DE, Leonti M. Ethnopharmacological field studies: a critical assessment of their conceptual basis and methods. J Ethnopharmacol. 2009;124:1–17. https://doi.org/10.1016/j.jep.2009.03.043.
120. World Health Organization (WHO). WHO guidelines on good herbal processing practices for herbal medicines. Available online: (accessed on 04/02).
121. Briggs AM, Woolf AD, Dreinhöfer K, Homb N, Hoy DG, Kopansky-Giles D, et al. Reducing the global burden of musculoskeletal conditions. Bull World Health Organ. 2018;96:366.

122. Khumalo GP, Van Wyk BE, Feng Y, Cock IE. A review of the traditional use of Southern African medicinal plants for the treatment of inflammation and inflammatory pain. J Ethnopharmacol. 2022;283:114436.
123. Bagdas D, Gul Z, Meade JA, Cam B, Cinkilic N, Gurun MS. Pharmacologic overview of chlorogenic acid and its metabolites in chronic pain and inflammation. Curr Neuropharmacol. 2020;18:216–28.
124. Tsang A, Von Korff M, Lee S, Alonso J, Karam E, Angermeyer MC, et al. Common Chronic Pain Conditions in Developed and Developing Countries: Gender and Age Differences and Comorbidity With Depression-Anxiety Disorders. J Pain. 2008;9:883–91. https://doi.org/10.1016/j.jpain.2008.05.005.
125. Pahwa, R.; Goyal, A.; Jialal, I. Chronic inflammation. 2018.
126. Edenta C, Okoduwa SI, Okpe O. Effects of aqueous extract of three cultivars of banana (Musa acuminata) fruit peel on kidney and liver function indices in wistar rats. Medicines. 2017;4:77.
127. Yadav A. Banana (Musa acuminata): Most popular and common Indian plant with multiple pharmacological potentials. World Journal of Biology Pharmacy and Health Sciences. 2021;7:036–44.
128. HO. Country cooperation strategy at a glance; 2018; pp. 1–2.
129. Stats SA. Mortality and causes of death in South Africa: Findings from death notification; 2018; pp. 1–159.
130. De Wet H, Ngubane S. Traditional herbal remedies used by women in a rural community in northern Maputaland (South Africa) for the treatment of gynaecology and obstetric complaints. S Afr J Bot. 2014;94:129–39.
131. Van Vuuren S, Frank L. Southern African medicinal plants used as blood purifiers. J Ethnopharmacol. 2020;249:112434.
132. Soriano JB, Kendrick PJ, Paulson KR, Gupta V, Abrams EM, Adedoyin RA, et al. Prevalence and attributable health burden of chronic respiratory diseases, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet Respir Med. 2020;8:585–96.
133. Teka A, Maryo M. Ethiopian medicinal plants used for respiratory tract disorders: ethnomedicinal review. Evidence-Based Complementary and Alternative Medicine. 2023;2023:7612804.
134. Liu N, Van der Kooy F, Verpoorte R. Artemisia afra: a potential flagship for African medicinal plants? S Afr J Bot. 2009;75:185–95.
135. Suliman S, Van Vuuren S, Viljoen AM. Validating the in vitro antimicrobial activity of Artemisia afra in polyherbal combinations to treat respiratory infections. S Afr J Bot. 2010;76:655–61.
136. Adeleye OA, Femi-Oyewo MN, Bamiro OA, Bakre LG, Alabi A, Ashidi JS, et al. Ethnomedicinal herbs in African traditional medicine with potential activity for the prevention, treatment, and management of coronavirus disease 2019. Future journal of pharmaceutical sciences. 2021;7:1–14.
137. Mashile SP, Tshisikhawe MP, Masevhe NA. Medicinal plants used in the treatment of maternal health-related problems by the Mapulana of Ehlanzeni District, Mpumalanga province, South Africa. Journal of Applied Pharmaceutical Science. 2019;9:021–9.
138. Davids D, Gibson D, Johnson Q. Ethnobotanical survey of medicinal plants used to manage high blood pressure and type 2 diabetes mellitus in Bitterfontein, Western Cape Province, South Africa. J Ethnopharmacol. 2016;194:755–66.
139. Nyakudya TT, Tshabalala T, Dangarembizi R, Erlwanger KH, Ndhlala AR. The potential therapeutic value of medicinal plants in the management of metabolic disorders. Molecules. 2020;25:2669.
140. Zhu X, Wang L, Zhao T, Jiang Q. Traditional uses, phytochemistry, pharmacology, and toxicity of Eriobotrya japonica leaves: A summary. J Ethnopharmacol. 2022;298:115566.
141. Maroyi A. Plants used for the management of paediatric ailments in Zimbabwe: A narrative review. Journal of Medicinal Plants for Economic Development. 2024;8:9.
142. Towns AM, Mengue Eyi S, van Andel T. Traditional medicine and childcare in Western Africa: mothers' knowledge, folk illnesses, and patterns of healthcare-seeking behavior. PLoS ONE. 2014;9:e105972.
143. Mofokeng MM, Araya HT, Amoo SO, Sehlola D, du Plooy CP, Bairu MW, et al. Diversity and Conservation through Cultivation of Hypoxis in Africa-A Case Study of Hypoxis hemerocallidea. Diversity. 2020;12:122.
144. Bijl A. The demography of Balanites maughamii: an elephant-dispersed tree. Cape-Toown: University of Cape-Town; 2012.
145. Francis JK. Naturalized exotic tree species in Puerto Rico, vol. Volume 82. US Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1991.
146. Lavoie C, Joly S, Bergeron A, Guay G, Groeneveld E. Explaining naturalization and invasiveness: new insights from historical ornamental plant catalogs. Ecol Evol. 2016;6:7188–98.
147. Hassan MO, Mohamed HY. Allelopathic interference of the exotic naturalized *Paspalum dilatatum* Poir. threatens diversity of native plants in urban gardens. Flora. 2020;266:151593.
148. Halder, M.; Jha, S. The current status of population extinction and biodiversity crisis of medicinal plants. In Medicinal Plants: Biodiversity, Biotechnology and Conservation; Springer: 2023; pp. 3–38.
149. Mamathaba, M.P. Botanical Efforts for a Comprehensive Assessment of Vascular Plant Diversity in South Africa; University of Johannesburg (South Africa): 2021.
150. Seile BP, Bareetseng S, Koitsiwe MT, Aremu AO. Indigenous Knowledge on the Uses, Sustainability and Conservation of African Ginger (Siphonochilus aethiopicus) among Two Communities in Mpumalanga Province. South Africa Diversity. 2022;14:192.
151. Adebayo SA, Amoo SO, Mokgehle SN, Aremu AO. Ethnomedicinal uses, biological activities, phytochemistry and conservation of African ginger (*Siphonochilus aethiopicus*): a commercially important and endangered medicinal plant. J Ethnopharmacol. 2021;266:113459.
152. Hamilton AC. Medicinal plants, conservation and livelihoods. Biodivers Conserv. 2004;13:1477–517.
153. Amujoyegbe B, Agbedahunsi J, Amujoyegbe O. Cultivation of medicinal plants in developing nations: means of conservation and poverty alleviation. Int J Med Aromat Plants. 2012;2:345–53.

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