Ethnomedicinal and conservation evaluation of the traditional medicinal plant species employed by the Van Gujjar Tribe in the Dehradun Shivalik Hills, Uttarakhand, India

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Research

Abstract

Background: To the best of our knowledge, this is the first quantitative and conservation ethnomedicinal evaluation of the Van Gujjar Tribe inhabited in the Delhi-Dehradun Highway Shivalik hills Belt (DHSB). The study area is situated adjacent to biodiversity hotspot Rajaji National Park, Uttarakhand, which is an important part of Himalayan systems. The area is ecologically sensitive, increasing anthropogenic disturbance and overexploitation of medicinal herbs is also major concern. So, along with conventional ethnobotanical studies, conservation analysis of the area is important.

Methods: This ethnomedicinal study comprised extensive field surveys and repetitive interviews of 120 informants of the Van Gujjar tribe with different social and educational backgrounds. Procured data were analyzed using three different quantitative indices, i.e. the relative frequency of citations (RFC), informant consensus factor (ICF), and the fidelity level (FL%). Collected plant samples were identified by relevant flora literature and online plant databases. Identified species conservation status was derived from The IUCN online database.

Results: A total of 71 medicinal plant species from 67 genera and 41 families were documented from the study area. The most frequently used species, *Zingiber officinale Azadirachta indica* A. Juss, and *Ageratum conyzoides* L. were employed for multiple health issues, mainly for digestive and respiratory disorders. The highest RFC values are *Z. officinale* (RFC = 1.0), *A. indica* A. Juss. (0.99) and *A. conyzoides* L. (0.92. FL% of these species were 96%, 90% and 83 % viz. The highest ICF value is 0.98, which shares dental & gum problems, digestive disorders and wounds categories. The IUCN status of 71 reported medicinal plant species indicated 28.1 % plant species were least concerned, 4.2 % critically endangered (*Chlorophytum borivilianum*,*Commiphora wightii, Nardostachys jatamansi*), 1.4 % near threatened and 1.4 % endangered, 2.8 % Data Deficient, while 61.9 % species status remained unknown

as currently not available in IUCN Red data list. Highly utilized species IUCN status however under 'least concerned' category.
Conclusions: The study aids medicinal plant species data with current conservation status in the Delhi-Dehradun Highway Shivalik hills Belt. Medicinal plant species such as *Chlorophytum borivilianum*, *Commiphora wightii*, and *Nardostachys jatamansi* are critically endangered and others could be prone due to overexploitation. The present data could help to fill the previous conservation and quantitative ethnobotanical studies gaps in the study area.

Keywords: Medicinal flora, Rajaji National Park**,** Himalaya, IUCN status**,** Critically Endangered Species, Traditional Knowledge,

Background

Ethnomedicinal studies have been helpful to understand traditional herbal medicine's potential healing aspects. Many phytochemicals and plant derivative-based studies derive their fundamental objectives from ethnomedicinal literature (Kumar *et al.* 2021). The demand for herbal medicinal products has increased incredibly over the past few years. Globally, around 80% of people rely on herbal medicinal products for primary healthcare (Ekor 2014). The key role of ethnic communities to sustain ancient herbalism cannot be overlooked. They have been a very preliminary source of learning and preserving herbal knowledge around the world. India is the home of biodiversity and many ethnic communities. Around 54 million tribal people belong to 645 indigenous tribes living in 5000 villages across the country (Nath *et al.* 2010). Studies have revealed that due to less documentation, traditional herbal knowledge could be extremely confined or extinct (Mahapatra *et al.* 2019). The Himalayas are known for diverse herbalism. In particular, the Indian Himalayan range is one of the 38 biodiversity hotspots in the world. Around 10,503 plant species have been reported from the Indian Himalayan area (Rana & Rawat 2017, Kumar & Chander, 2018). Despite extensive botanical studies in the region, some parts of the lower Himalayan Shivalik hills are not fully explored from an ethnomedicinal and conservation perspective.

Geographically, the Shivalik hills are an outer Himalayan mountain range that spread over 1600 km from the Teesta River region of Sikkim, Nepal westward, Uttarakhand, Kashmir to Northern Pakistan. Shivalik hills are considered the youngest mountain range in the Himalayan system. The Shivalik hills range belt cuts through several important perennial and rain-faded rivers which flow toward the south from the Himalayas. In India, Shivalik hills cross the borders of several northern states such as Uttarakhand, Uttar Pradesh (Saharanpur district), Haryana (Panchkula and Yamunanagar district), Himachal Pradesh, Punjab, and Jammu & Kashmir. In a previous study, Sharma et al reported around 323 plant species in the Indian Shivalik belt (Sharma *et al.* 2015). Later, around 200 species were reported in the Himachal Pradesh belt of Shivalik hills (Kumar & Chander 2018), and 77 medicinal plant species from the Panchkula Shivalik range (Balkrishna *et al.* 2022). It is noticeable that some medicinally important plant species from the same region have become endangered and many are under threatening conditions due to overexploitation (Bahukhandi *et al.* 2018). The traditionally important medicinal species could be in alarming condition due to overexploitation and overlooked conservation status. So, along with the conventional ethnobotanical studies, the conservation status also needs to be addressed. Delhi-Dehradun Highway Shivalik Belt (DHSB) is one such Shivalik hill important area where ethnobotanical aspects, medicinal plants conservation status, and role of tribal communities have less documented so far. The tribes, mainly Van Gujjar has been an integrated tribe in this area of Shivalik hill system. Yet, they are only known as suppliers of milk and milk products in the region (Gooch 2004, Sharma *et al.* 2012). Van Gujjars rely on local flora and fauna for primary healthcare, so it is important to report their traditional medicinal knowledge and association with local flora conservation.

The present study aimed to collect ethnomedicinal knowledge from the Van Gujjar tribe in the Delhi-Dehradun Highway Shivalik Belt (DHSB) and to highlight the utilized medicinal plant species conservation status and potential overexploitation threat.

Material and Methods

The study was conducted on the outskirts of the Delhi-Dehradun Highway Shivalik Belt (DHSB), Uttarakhand, India. The study comprised interview sessions of the Van Gujjar tribe and field surveys, which were conducted between April 2019 to March 2020 to ensure the correct identification of seasonal plant species. Plant specimens were collected, pressed, and labeled immediately in the field and deposited at the Company's Garden Saharanpur.

Informants inclusion criteria were based on their knowledge of traditional medicine. For plant sample identification, Flora of the District Garhwal (Gaur 2001) and Flora of Pan-Himalaya were used (Hong 2015). For further updated nomenclature, botanical families, and accepted name status, online plant databases such as Plants of the World

Online Species, and International Plant Names Index were used (POWO 2022, IPNI 2022). Oral consent from informants and local authorities was taken before the study. No minor was involved in this study.

For quantitative analysis and to elaborate the results, convectional ethnobotanical parameters such as Relative Frequency of Citation (RFC), Informant Consensus Factor (ICF), and Fidelity level (FL) were used. The conservation status of collected plant samples was derived from the International Union for Conservation of Nature Red List of Threatened Species database (IUCN 2022).

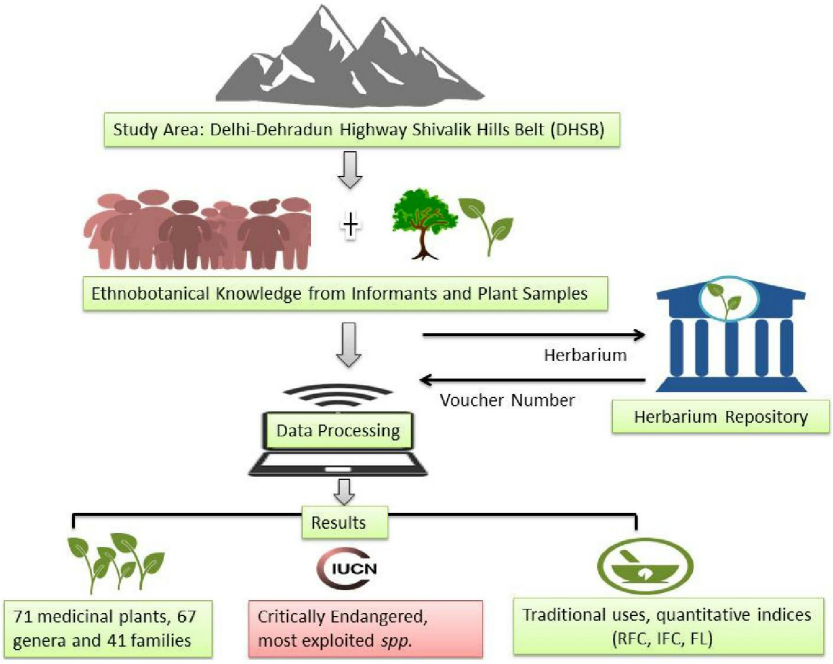

Figure 1. Schematic flow chart of the study plan

Socio-Demographical Status of the informants

120 informants (80 males and 40 females), aged between 20-50 years, participated in this study. Most of the informants were married (91.1%). Their education level was diverse, 55% of them did not have any formal education, 27.5 % attended school up to the primary level, and 16.6 % had formal education in secondary school. Their employment status was also varied. 71% were unemployed (did not work in public and private sectors) and did not have a regular source of income, though they engaged in different traditional practices such as herding, daily product selling, etc. While 20.8% earn 5000-8000 ₹ /month and 7.5 % earn 8000-12000 ₹ /month regularly (Table 1).

Table 1. Demographical Details of the Van Gujjar Tribe

Variables	**Categories**	**Total number**	**Percentage** %
Gender	Male	80	66.6
	Female	40	33.4
Age	20-40 Years	70	58.3
	40-50 Years	30	25
	>50 Years	20	16.6
Marital Status	Married	110	91.1
	Divorced	10	8.3
	Unmarried	0.0	0.0
Education Level	Illiterate	67	55
	Primary School	33	27.5
	Secondary School	20	16.6
Income/Month	Unemployed	86	71
	5000-8000	25	20.83
	8000-12000	9	7.5

Study Area

The study area, Delhi-Dehradun Highway Shivalik Belt (DHSB), is situated adjacent to the conserved forest area of Raja Ji National Park Range, Uttarakhand, India. This area is considered one of the biodiversity-rich zones of the Shivalik hills. Due to the ecologically sensitive zone and biodiversity hotspot, nearby areas have been protected under Rajaji National Park, one of the most popular national parks in India, known for its diverse flora-fauna, and activities such as tiger and elephant safari. The national park was established in 1982.The van Gujjar is the only nearest tribe to reside outside but close to the park for decades, mostly at the western edge (30°03′29″N latitude and 78°10′22″E longitude) (Figure 2). The area is located near the Delhi-Dehradun Highway.

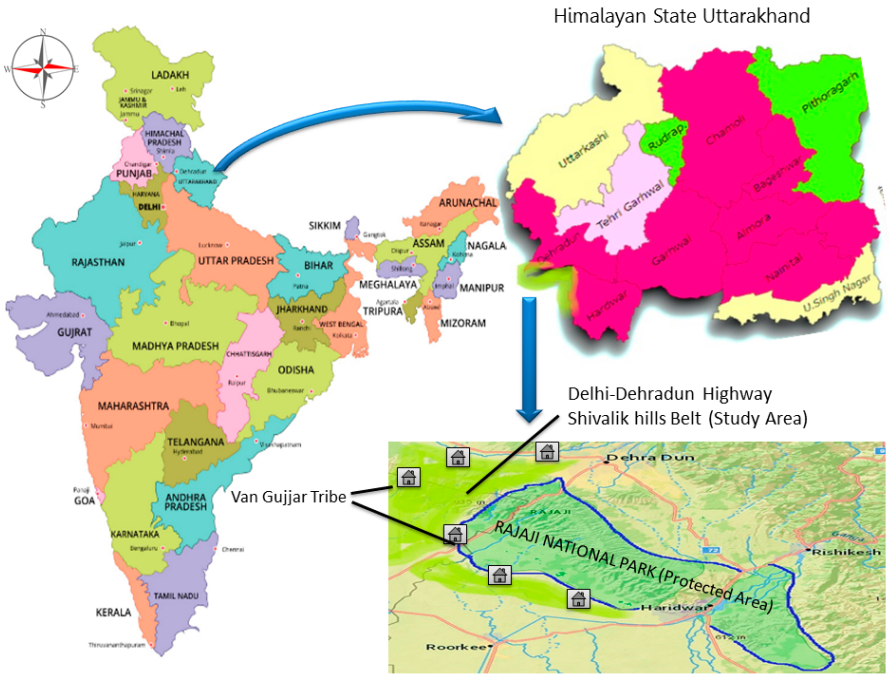

Figure 2. Geographical Location of the Study Area and Van Gujjar Tibe in Shavalik Hills

Relative Frequency of Citation (RFC) of Medicinal Plants

RFC values show the importance of a specific medicinal plant species in the concerned tribe or locality. The higher the RFC value, it indicates the usefulness of medicinal plants; usually '0' indicates no informants mention it as useful and '1' when all informants referred to a plant as useful.

$$RFC = FC / N$$

Where

N= Number of all informants, and FC= Frequency of Citations by informants.

The frequency of citations (FC) by the van Gujjar tribe who participated in this study was divided by their total number (N) (Tardío & Pardo-de-Santayana 2008).

Informant Consensus Factor (ICF)

ICF is used to figure out the level of agreement among the informants, about the uses of medicinal plants to treat specific diseases.

$$ICF = Nur - Nt/(Nur - 1).$$

Where,

Nur is the numbers of reports, and Nt is the total number of species sed for a diseases category. A higher value indicates a high rate of agreement between the informants, a low one a low degree of agreement (Heinrich *et al.* 1998).

Fidelity level (FL)

FL is the quantities representation of the informants who mentioned the uses of plant species to treat the particular ailment. It is calculated by

$$FL\ \% = Np/ N \times 100$$

Where,
Np is the number of informants who claimed the use of plant species for a particular medicinal treatment.
N is the total number of informants who cited the plant species for various kinds of medicinal treatment (Srithi *et al.* 2009, Jadid *et al.* 2020)

Medicinal Plants Identification and their Conservation status
To preserve the collected plant specimen, standard procedures such as drying, and mounting were followed. Collected medicinal plants were listed alphabetically with respective scientific, vernacular names and ethno-medicinal uses. The identification of plants is done by using related flora's literature (Flora of the District Garhwal and Flora of Pan-Himalaya) and online plant database Plant of the World Online and International Plant Names Index.

Identified plant samples were further evaluated for conservation status, according to the online International Union for Conservation of Nature Red List of Threatened Species database.

The voucher number for specimens were permitted by Saharanpur Botanical garden (Company's Garden). Collected information was further processed and analyzed by using Microsoft Office Excel 2016. The graphs, original images, illustrations were edited in Microsoft Power Point and Paints. The categories suggested for diseases were classified according to WHO's International Classification of Primary Care (ICPC).

Results and Discussion

Enumeration of reported medicinal plants
A total 71 medicinal plant species that belong to 67 genera and 41 families were reported in the DHSB. These species were being employed to treat several common and debilitating diseases by the Van Gujjar tribe in the study area (Figure 3, Table 2).

Figure 3. Study Area: Field Visiting and herbs Collection (A),Van Gujjar Summer huts near Dehradun-Delhi Highway (B), glimpses of van Gujjar Interview (C, D).

Table 2. Reported medicinal plant species details

Family	Scientific name	Vernacular Names	Parts & Medicinal Uses	IUCN Status	Voucher Specimen	RFC	FL %
Acanthaceae	*Justicia adhatoda* L.	**Bassa, Vasa**	Leaves decoction used for respiratory disorders	LC	SCG-390	0.64	17%
Amaranthaceae	*Achyranthes aspera L.*	**Charchita, Apamarg**	Roots wear as garland in neck to treat Hepatitis	NA	SCG-011	0.33	25%
Amaranthaceae	*Amaranthus viridis L.*	**Chulai, Cholai**	Leaf used as vegetables in weakness	NA	SCG-062	0.55	37%
Amaranthaceae	*Chenopodium album L.*	**Bathua**	Leaves are used as vegetables in Anemia	NA	SCG-210	0.67	29%
Apiaceae	*Centella asiatica* (L.) Urb.	**Mandookparni**	Leaves in skin and blood disorders	LC	SCG-207	0.32	15%
Apocynaceae	*Catharanthus roseus* (Linn.) G. Don	**Sadabahar**	Leaves for diabetes, cancer	NA	SCG-197	0.56	28%
Apocynaceae	*Gymnema sylvestre* (Retz.) R.Br. ex Sm.	**Gudmar**	Dried leaves, stem, root for diabetes	LC	SCG-367	0.54	29%
Apocynaceae	*Holarrhena pubescens* Wall. Ex G.Don	**Kurchi, Kutaj**	Fruits and leaves for dysentery, colitis	LC	SCG-378	0.17	14%
Apocynaceae	*Leptadenia reticulate* (Retz.) Wight & Arn.	**Jivanti**	Roots and leaves for TB, respiratory and cardiac disorders	NA	SCG-398	0.42	15%
Apocynaceae	*Rauvolfia serpentine* (L.) Benth. Ex Kurz	**Sarpgandha**	Roots are used for children growth, infection	NA	SCG-533	0.10	13%
Asparagaceae	*Asparagus racemosus* Willd.	**Satavar**	Roots powder for sexual disorders	NA	SCG-085	0.58	38%
Asparagaceae	*Chlorophytum borivilianum Santapau* & R.R.Fern.	**Shwet Musali**	Root for sexual disabilities	CR	SCG-216	0.24	20%
Asphodelaceae	*Aloe vera* (L.) Burm.f.	**Ghee Kumar, ghratkumari**	Leaves pulp for skin and blood disorders, mouth sore	NA	SCG-054	0.64	45%
Asteraceae	*Ageratum conyzoides L.*	**Sadandh Ghass**	Leaf juice for Fresh cuts, wounds, metal injury, bleeding	NA	SCG-044	0.92	83%
Asteraceae	*Artemisia annua* L.	**mastaru**	leaves decoction for fever	NA	SCG-078	0.23	15%
Asteraceae	*Eclipta prostrata* (L.) L	**Ajagara, Bringaraj**	Whole plant used for hair fall	NA	SCG-283	0.24	16%
Asteraceae	*Inula reticula* Hook.f.	**Pushkarmool**	Leaves decoction for chest pain	NA	SCG-385	0.02	9%
Basellaceae	*Basella alba L.*	**Koi ki bel, Poi**	Used as vegetable for weakness	NA	SCG-137	0.43	20%
Berberidaceae	*Berberis aristata* DC.	**Daruhaldi**	Leaves for skin infection, kidney stone	LC	SCG-153	0.34	25%

Berberidaceae	*Podophyllum hexandrum* Royle	**Bankakri**	Leaves and root are used as purgative in constipation	NA	SCG-521	0.02	8%
Bignoniaceae	*Oroxylum indicum* (L.) Kurz	**Syonaka**	Leaves and root are used to treat liver and gastric disorders	NA	SCG-490	0.025	10%
Burseraceae	*Commiphora wightii* (Arn.) Bhandar	**Guggal**	Leaves for stomach disorders; latex and bark for skin infection	CR	SCG-244	0.58	65%
Capparaceae	*Crataeva nurvala* Buch – Ham.	**Varun**	Leaves for digestive complaints	NA	SCG-266	0.33	14%
Caprifoliaceae	*Nardostachys jatamansi* (D.Don) DC.	**Jatamansi**	Root, Fruit for hair fall	CR	SCG-461	0.12	14%
Celastraceae	*Celastrus paniculatus* Willd.	**Malkangani, Jyothismathi**	Leaves and root in Anemia	NA	SCG-203	0.38	18%
Colchicaceae	*Gloriosa superba* L.	**Agni, Agnishikha**	Leaves and flowers for snake bite	LC	SCG-319	0.24	17%
Combretaceae	*Terminalia arjuna* (Roxb. Ex DC.) Wight & Arn.	**Arjun**	Bark, leaves for heart and digestive disorders	NA	SCG-587	0.44	31%
Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	**Behera**	Seed powder for liver and gastric Disorders	NA	SCG-588	0.66	49%
Combretaceae	*Terminalia chebula* Retz	**Harad**	Seed powder for liver and gastric disorders	NA	SCG-590	0.66	43%
Convolvulaceae	*Convolvulus reticulate* Forssk.	**Shankhpushpi**	Leaves for brain weakness	NA	SCG-250	0.45	33%
Dioscoreaceae	*Dioscorea bulbifera* L.	**Rotalu, Gethi**	Leaves decoction and root powder for Diabetes	NA	SCG-277	0.47	19%
Elaeagnaceae	*Hippophae rhamnoides* L.	**Brahmaphal**	Fruits for blood disorders	LC	SCG-369	0.0 16	11%
Euphorbiaceae	*Euphorbia tithymaloides L.*	**Palchita, Naagdon**	Latex from leaves and stem used topically for insect bites	LC	SCG-307	0.44	35%
Euphorbiaceae	*Ricinus communis* L.	**Arand, Arandi**	Leaves wrapped as plaster for broken bone	NA	SCG-569	0.66	12%
Fabaceae	*Abrus precatorius* L.	**Chinnoti, Ladai-ladai**	Consider toxic, Seeds ash and root powder taken for cancer	NA	SCG-010	0.24	14 %
Fabaceae	*Albizia lebbeck* (L.) Benth.	**Shirish**	Root and leaves as brain tonic	LC	SCG-009	0.43	18%
Fabaceae	*Cassia angustifolia* Vahl.	**Senna**	Fruit for stomach disorders	NA	SCG-184	0.43	31%
Fabaceae	*Clitoria ternatea* L.	**Aparajita**	Leaves as anxiolytic and brain tonic	NA	SCG-229	0.44	17%
Fabaceae	*Glycyrrhiza glabra* L.	**Mulethi**	Stem, bark used for liver and digestive disorders	LC	SCG-333	0.58	28%
Fabaceae	*Mucuna pruriens* (L.) DC.	**Konch**	Roots for infertility	NA	SCG-455	0.24	15%

Fabaceae	*Pleurolobus gangeticus* (L.) J.St.-Hil. Ex H.Ohashi & K.Ohashi	**Sarivan**	Leaves for fever, infections	NA	SCG-513	0.016	12%
Fabaceae	*Pueraria tuberosa* (Roxb. Ex Willd.) DC.	**Vidarikand**	Tuberous root used as tonic in weakness	NA	SCG-529	0.03	8%
Fabaceae	*Senegalia catechu* (L.f.) P.J.H.Hurter & Mabb.	**Katha**	Stem for diarrhea, dysentery, mouth sore, skin inflammation	L C	SCG-574	0.24	23%
Gentianaceae	*Swertia chirayita* (Roxb.) H.Karst.	**Chirata, Charayatah seed**	Seeds and leaves for liver ailment	NA	SCG-580	0.02	10%
Lamiaceae	*Gmelina arborea* Roxb. Ex Sm.	**Gambhari**	Leaves for weakness	LC	SCG-350	0.23	23%
Lamiaceae	*Ocimum tenuiflorum* L.	**Tulsa**	Leaves and seed as febrifuge for fever	NA	SCG-488	0.74	49%
Lamiaceae	*Vitex negundo* L.	**Nirgundi, Nirguni**	Leaves decoction used for respiratory and blood disorders	NA	SCG-600	0.50	49%
Lauraceae	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & C.H.Eberm.	**Tejpatta**	Leaves in digestive complaints	LC	SCG-221	0.23	21%
Meliaceae	*Azadirachta indica* A.Juss.	**Neem**	All part as antiseptic for wounds, blood disorders, snake bite. Stem for Dental and gum infection	LC	SCG-121	0.99	90%
Menispermaceae	*Tinospora cordifolia* (Willd.) Hook.f. & Thomson	**Gioly, Gilo**	Leaves, stem for fever	NA	SCG-598	0.79	80%
Moringaceae	*Moringa oleifera* Lam.	**Shehjan**	Leaves, flowers, stem as tonic, nutritive	LC	SCG-411	0.28	13%
Myrtaceae	*Psidium guajava L.*	**Amrud**	Leaves decoction and roasted Fruits used for cough and flu	LC	SCG-510	0.82	77%
Myrtaceae	*Syzygium cumini* (L.) Skeels	**Jaman, Jamun**	Leaves paste eaten in Amoebiasis and diarrhea	L C	SCG-583	0.32	29 %
Nyctaginaceae	*Boerhavia diffusa* L.	**Punarnava**	Leaves eaten as vegetable for liver disorders	NA	SCG-171	0.75	77%
Phyllanthaceae	*Phyllanthus amarus Schumach.* & Thonn.	**Bhumiamla**	Leaves and fruits are used for liver diseases	NA	SCG-495	0.46	14%
Phyllanthaceae	*Phyllanthus emblica* L.	**Amla**	Dried fruit powder for digestive and blood disorders	LC	SCG-498	0.76	65%
Plantaginaceae	*Bacopa monnieri* (L.) Wettst.	**Brahmi**	Leaves decoction as brain tonic	LC	SCG-141	0.57	26%

Plantaginaceae	*Picrorhiza kurroa* Royle ex Benth.	**Kutki**	Leaves and bark are used as cardiac tonic	NA	SCG-502	0.42	31%
Polygonaceae	*Rheum webbianum* Royle	**Archa**	Roots and leaves for Cancer, kidney problems	NA	SCG-565	0.03	7%
Primulaceae	*Embelia ribes* Burm. F.	**Baibedang, VaiVidang**	Leaves for digestive and joint problems	NA	SCG-294	0.34	19%
Ranunculaceae	*Aconitum ferox* Wall. ex Ser.	**Vatsnabh**	Leaves extract for ear -nasal Infection	NA	SCG-009	0.016	23%
Ranunculaceae	*Aconitum heterophyllum* Wall. ex Royle	**Atees**	Leaves for fever	EN	SCG-021	0.08	17%
Rubiaceae	*Rubia cordifolia* L.	**Manjishtha**	Dried leaves and root are used for skin disorders	NA	SCG-570	0.56	27%
Rutaceae	*Aegle marmelos* (L.) Corrêa	**Beal**	Fruit pulp for stomach disorders	NT	SCG-032	0.75	48%
Rutaceae	*Zanthoxylum alatum* Roxb.	**Timoor, Timru**	Leaves and stem for dental and gum problems	NA	SCG-636	0.24	35%
Saxifragaceae	*Bergenia ciliata* (Haw.) Sternb.	**Pashnabheda**	Leaves for Digestive ailments	LC	SCG-160	0.24	26%
Smilacaceae	*Smilax china* L.	**Hrddhatri**	Leaves for Arthritis	NA	SCG-577	0.01	6%
Solanaceae	*Atropa bella-donna* L.	**beldone**	Leaves and seed as sedative, antispasmodic	NA	SCG-098	0.24	22%
Solanaceae	*Withania somnifera* (Linn.) Dunal	**Ashwagandha**	Root and leaves powder for general weakness and brain disorders	Data Deficient	SCG-617	0.33	39%
Violaceae	*Viola odorata* L.	**Banafsha, vanafsha, Gul Banafsha**	Dried leaves, stem for fever and headache	NA	SCG-603	0.33	37%
Zingiberaceae	*Zingiber officinale* Roscoe	**Sonth, Adrakh**	Tuberous root for respiratory, digestive and sexual disorders	Data Deficient	SCG-640	1.00	96%

Fourty-one plant families and number of associated species: *Acanthaceae* (1 sp.)*Amaranthaceae* (3 sp.), *Apiaceae* (1 sp.), *Apocynaceae* (5 pp.), *Asparagaceae* (2 pp.), *Asphodelaceae* (1 sp.), *Asteraceae* (4 sp.), Basellaceae (1 sp.), *Berberidaceae* (2sp.), *Bignoniaceae*(1sp.), *Burseraceae* (1 sp.), *Capparaceae* (1 sp.), *Caprifoliaceae* (1 sp.), *Celastraceae* (1 sp.), *Colchicaceae* (1 sp.), *Combretaceae* (3 spp.), *Convolvulaceae* (1 sp.), *Dioscoreaceae* (1 sp.), *Elaeagnaceae* (1 sp.), *Euphorbiaceae* (2 sp), *Fabaceae* (9 spp.), *Gentianaceae* (1 sp.), *Lamiaceae* (3 spp.), *Lauraceae* (1 sp.), *Meliaceae* (1 sp.), *Menispermaceae* (1 sp.), *Moringaceae* (1 sp.), *Myrtaceae* (2 spp.), *Nyctaginaceae* (1 sp.), *Phyllanthaceae* (2 sp.), *Plantaginaceae* (2 sp.), *Polygonaceae* (1 sp.), *Primulaceae* (1 sp.), *Ranunculaceae* (3 sp.), *Rubiaceae* (1 sp.), *Rutaceae* (2 sp.), *Saxifragaceae* (1 sp.), *Smilacaceae* (1 sp.), *Solanaceae* (2 spp.), *Violaceae* (1 sp.), and *Zingiberaceae* (1 sp.) showed most plant species belong to different plant families. Though, *Apocynaceae* and *Fabaceae* represents have highest number of species (Figure 4).

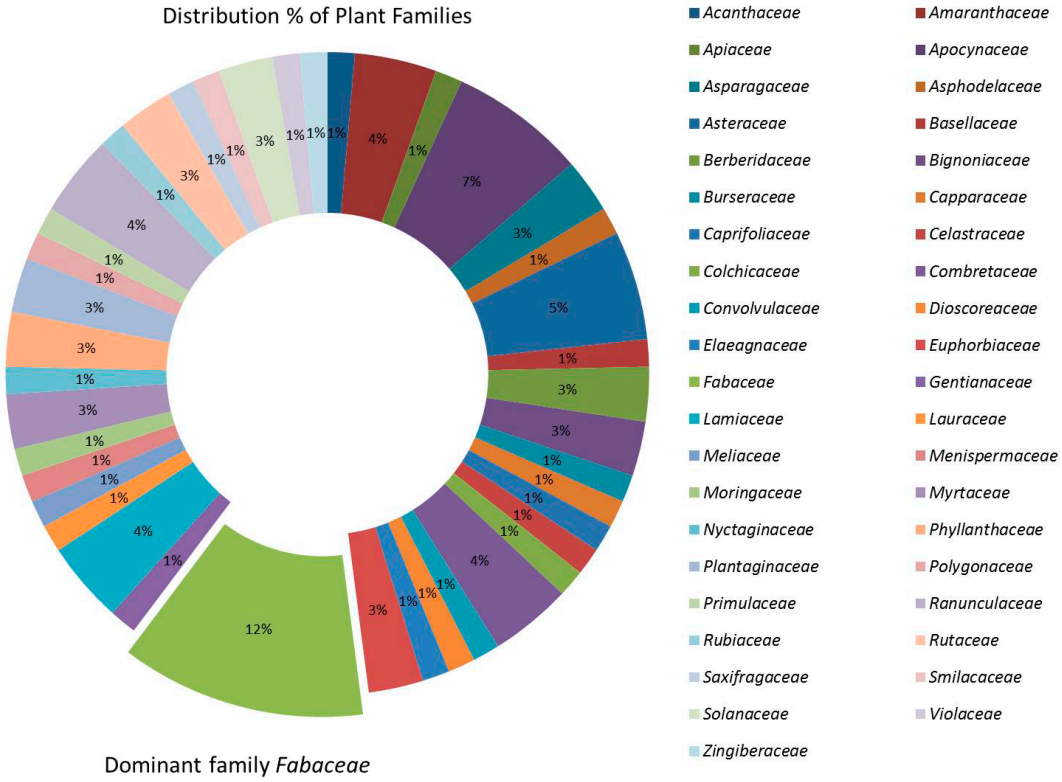

Figure 4. Reported 41 plant families' frequencies in the study area.

A recent ethnobotanical study in the nearby region Raja ji National Park, Haridwar Shivalik region, reported 68 potentially medicinal plants and 32 associated families where the most dominant plant families include *Fabaceae* (5 species), followed by *Caesalpiniaceae, Fabaceae, Mimosaceae, Asteraceae, Combretaceae, Euphorbiaceae, Rutaceae, Acanthaceae, Myrtaceae, Moraceae, Lamiaceae* (Sharma et al. 2022). *Fabaceae* was the most dominant plant family in the study area DHSB and in the adjacent Shivalik region. Different parts of the reported plant species were associated with various medicinal uses. However, leaves and roots were the most used parts, followed by stems, seeds, fruits, flowers and fruits (Figure 5).

Relative Frequency of Citation (RFC) of the Reported Plant Species

RFC values of reported plant species listed in Table 2. *Zingiber officinale* (RFC = 1.0), *Azadirachta indica* Juss. (0.99) and *Ageratum conyzoides L.* (0.92) showed highest RFC values which was followed by *Psidium guajava L*(0.82*), Tinospora cordifolia* (Willd.) Hook.f. & Thomson (0.79), *Phyllanthus emblica* L.(0.76), *Aegle marmelos* (L.) Corrêa (0.75), *Boerhavia diffusa* L. (0.75), *Ocimum tenuiflorum* L. (0.74), *Chenopodium album L.* (0.67*),Ricinus communis* (0.66*), Terminalia bellirica* (Gaertn.) Roxb (0.66), *Terminalia chebula* Retz (0.66), *Justicia adhatoda* L. (0.64), *Commiphora wightii* (Arn.) Bhandar (0.58), *Glycyrrhiza glabra* L. (0.58) and so on. RFC data suggests *Zingiber officinale, Azadirachta indica* Juss, and *Ageratum conyzoides* L. were the most familiar and frequently used plant species in study area.

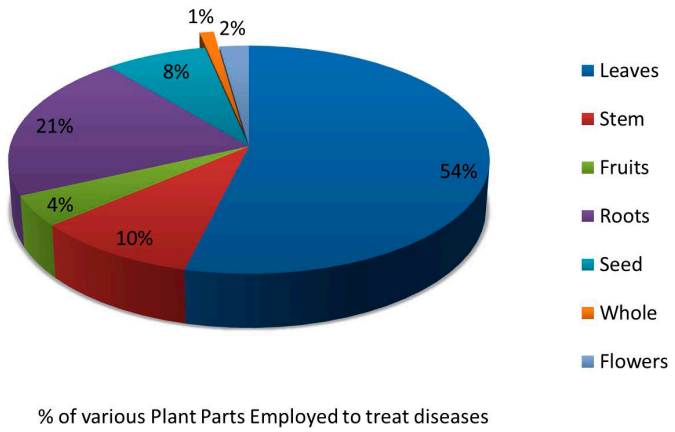

Figure 5. Proportion of the Various Parts of Reported Medicinal Plant species

Informant Consensus Factor (ICF)

Qualitative analysis of this ethnomedicine study use 21 main ailments and categories of diseases (Table 3). To figure out the level of agreement among the informants of Van Gujjar tribe about the uses of medicinal plants to treat listed diseases, ICF values were reported. ICF values and its corollary components such as number of plants used for a particular disease category, frequency of reports are included in Table 3.

Table 3 Categories of diseases and related Informant Consensus Factors (ICF)

Diseases Categories	**Number of Taxa (Nt)**	**Number of Use Reports (Nur)**	**Informant consensus factor (ICF)**
Cancer	3	29	0.92
Respiratory disorders & Infection: Cough, tuberculosis and flu	7	94	0.93
Gastric disorders: Amoebiasis, diarrhea, Dysentery, colitis, stomach problems	10	73	0.87
Digestive Disorders: indigestion, constipation	2	67	0.98
Sexual Disorders: infertility,	4	33	0.90
Fever	6	68	0.92
Pain: Headache, chest pain	2	49	0.97
Blood disorders: Anemia	8	22	0.66
Brain disorders	5	48	0.91
Hepatic Disorders: Liver issues, Hepatitis, Jaundice	8	89	0.92
Cardiac ailments: heart diseases	3	56	0.96
Diabetes	3	65	0.96
General Debilities: impaired growth, Weakness	7	71	0.91
Bone and Joints problems	3	70	0.97
Skin & Hair Problems	8	25	0.70
Mouth Sore	2	27	0.96
Infections: Skin, Nasal	5	19	0.77
Wound: cut, injuries, external bleeding	2	68	0.98
Kidney ailments: Calculi	2	16	0.93
Snake bite	2	24	0.95
Dental & Gum Problems	2	77	0.98

The ICF value showed variation, 0.98 to 0.66. To the treatment of categorized ailment the highest ICF value is 0.98 which shares digestive disorders, dental & gum problems and wounds categories, related species details are given in Table 2. Whilst the lower agreement (ICF= 0.66) between informants was for the plants used for blood disorders (Figure 6). The high ICF values in the study area suggest that such species are worth to investigating for further pharmacological and phytochemical active compounds.

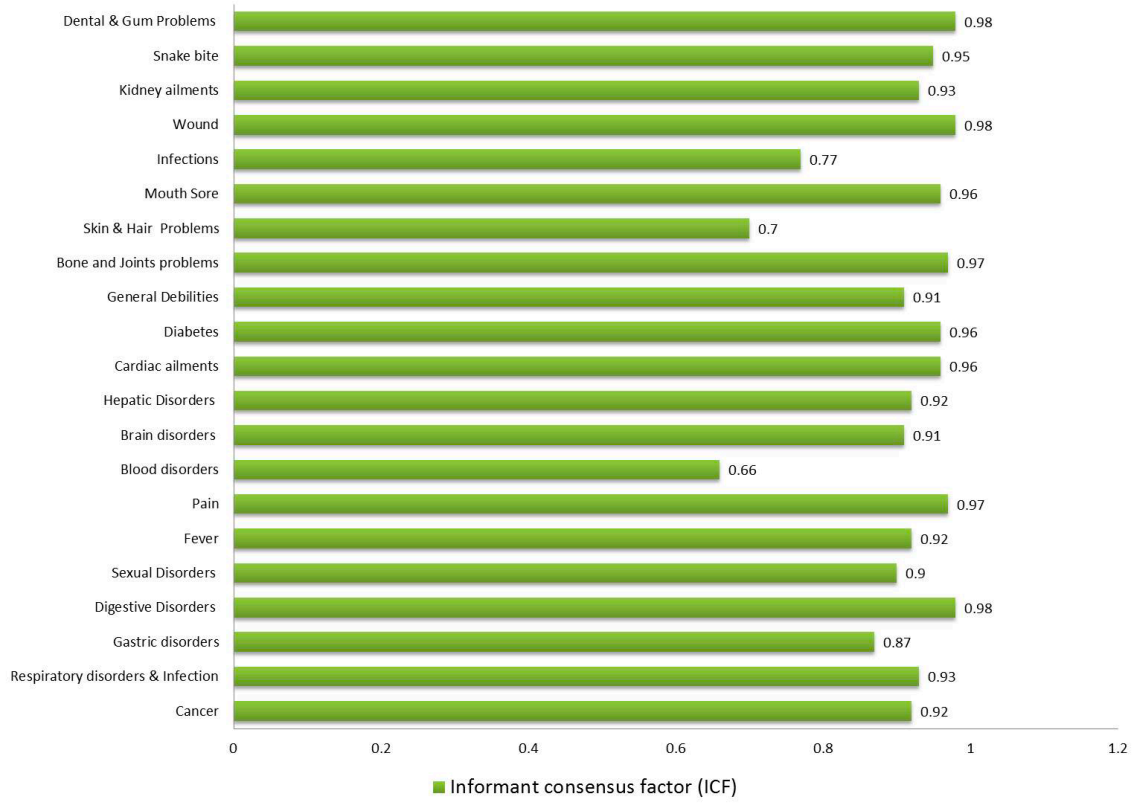

Figure 6. Diseases categories and respective ICF values of employed plant species

Fidelity Level

The high percentage of fidelity level (FL%) showed the importance of a particular species in the studied region. Although, in this study we found the relation between RFC and FL valueshigh RFC species also have a high FL% in Table 1. *Zingiber officinale* (FL = 96%), *Azadirachta indica* A. Juss.(FL = 90%) and *Ageratum conyzoides* L. (FL= 83%) showed highest FL%. While *Smilax china* L. (6%), *Rheum webbianum* Royle (7%) *Podophyllum hexandrum* Royle (8%) have lowest FL and RFC values as well, Figure 7.

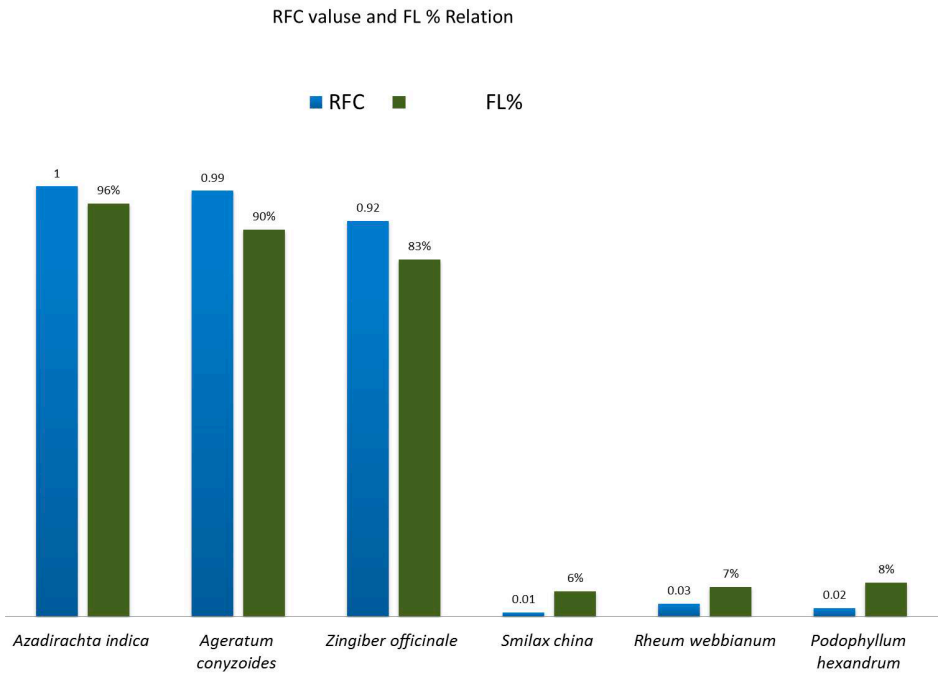

Figure 7. Relations between Highest and Lowest RFC and FL Values of Reported Medicinal Plant Species

Out of 77 reported plant species, *Zingiber officinale*, *Azadirachta indica* A. Juss. and *Ageratum conyzoides* L. showed the highest RFC and FL values.

The Van Gujjar tribe employed *Azadirachta indica* all parts as an antiseptic agent leaves particularly used as an ointment for wounds, blood disorders, and snake bites. Stems were used for dental and gum infections. *Zingiber officinale* tuberous root was used as dried or fresh mainly for respiratory, digestive, and sexual ailments. While *Ageratum conyzoides* leaf was used only for external cuts, wounds and metal injuries.

All these three species have been studied extensively and shown numerous promising pharmacological activities. For instance, *Z. officinale* has been employed in ancient Chinese, African and Ayurvedic medicine to treat many ailments such as flu, common cold, pain, respiratory disorders, fever, nausea, gynecological problems, digestive disorders, diarrhea, rheumatism, dental and gum problems and parasitic infestation Mbaveng & Kuete 2017). A variety of pharmacological active compounds, such as Zingerone, gingerol, zingiberene, β-sesquiphellandrene, β-phellandrene, farnesene, 1,4-cineol, citral, camphene, 6-paradol, curcumene, terpineol, borneol, β-elemene, zingiberenol, limonene, geraniol linalool were responsible the specific smell, taste and pharmacological activities (Mbaveng & Kuete, 2017).

Current studies showed substantial pharmacological potential of *Z. officinale* including anti-oxidant, anti-inflammatory, anti-microbial, anti-cancer, neuro-protective, cardiovascular protective, respiratory protective, anti-obesity and anti-diabetic activities (Ramakrishnan, 2013, Mao et al., 2019); anti- Pro-fertility and androgenic activities in male rats also observed (Morakinyo *et al.* 2008).

Similarly, *Azadirachta indica*, which is native to Indian subcontinent, has been employed against a wide variety of ailments. Traditionally, *A. indica* was considered as the village pharmacy due to its broad range of medicinal applications, such as respiratory problems, rheumatism, chickenpox, jaundice, cancer, diabetes, heart ailments and gastrointestinal disorders. Many bioactive phytochemicals of *A. indica*, such as alkaloids, limonoids, terpenoids, reducing sugar, gallic acid, flowerone, diepoxyazadirol, catechins, sterols and flowerine (Gurme et al. 2022). Studies shows more than 300 chemical constituents have been identified from *A. indica* (Gupta *et al.* 2017).

The 3rd most frequently employed species, *Ageratum conyzoides* is an invasive species in the study area. Due to the sharp pungent aroma, the herb locally called 'Sadhand Ghass' means 'Stink Grass' The herb usually not grazed by animal. Van Gujjar tribe used fresh leaves extract to stop bleeding from fresh cuts and metal injuries (figure 8).

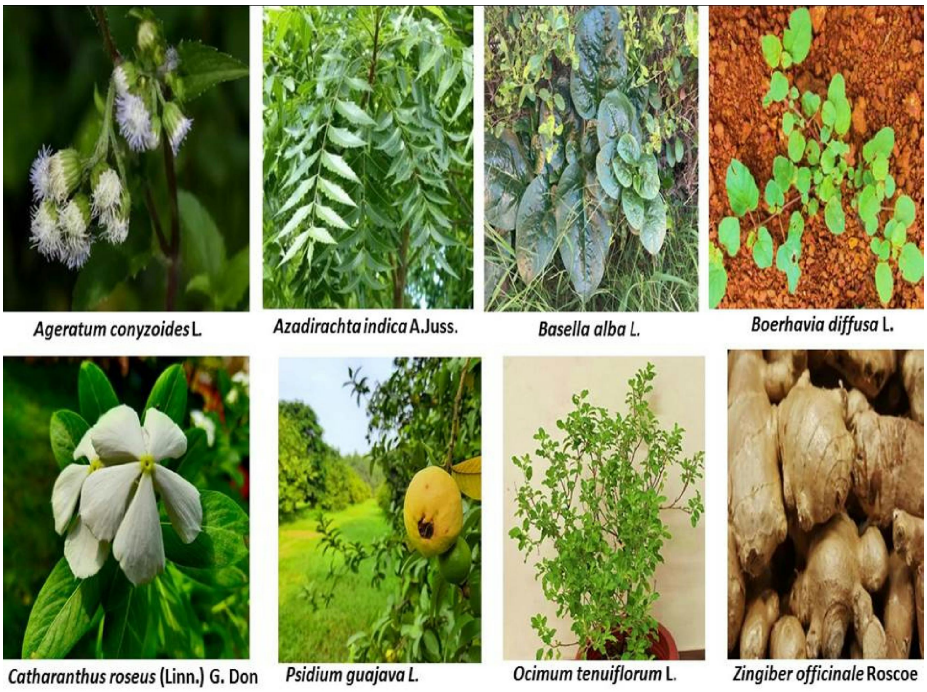

Figure 8. Most frequently employed medicinal and edible plant species by The Van Gujjar Tribe

Ageratum conyzoides has previously been documented for various external ethnomedicinal uses for skin disorders, leprosy, pneumonia and rheumatism. Numerous phytoconstituents from *A. conyzoides* have also shown diverse pharmacological activities such as analgesic, anti-microbial, anti- inflammatory, anti-oxidant, anti-cancer, anti-protozoal, anti-diabetic and spasmolytic (Yadav *et al.* 2019).

According to the recent findings *A. conyzoides* could be used as a biological insecticide, especially against endemic *Aedes aegypti* mosquitoes (Pintong *et al*, 2020).

All reported medicinal plant species were being employed for multiple traditional medicinal applications in the study area. These species possibly have other multiple healing potentials which was not documented in this study. While the most popularly used species, *Zingiber officinale*, *A. indica* and *A. conyzoides*, represent a phenomenal potential candidacy for present and future phytochemical medicines.

Current IUCN Status of the reported Medicinal Plants

The IUCN Red List Status of the 71 reported medicinal plant species (figure 7) was varied. 44 species' status (61.9 %) was vague as we did not find them in the IUCN online database. Moreover, the species were searched for their common names and synonyms, yet their IUCN status remained unclear, shown as NA (Not Available) in Table 2. Overall, 38 % species IUCN status reported out of them as 20 plant species (28.1 %) were Least Concerned (LC), 3 species (4.2 %) Critically Endangered (*Chlorophytum borivilianum.*,*Commiphora wightii, Nardostachys jatamansi*,), one (1.4 %)Near Threatened (*Aegle marmelos*) and one (1.4 %) Endangered (*Aconitum heterophyllum*), 2.8 % data deficient (*Zingiber officinale*, *Withania somnifera*) (figure 9).

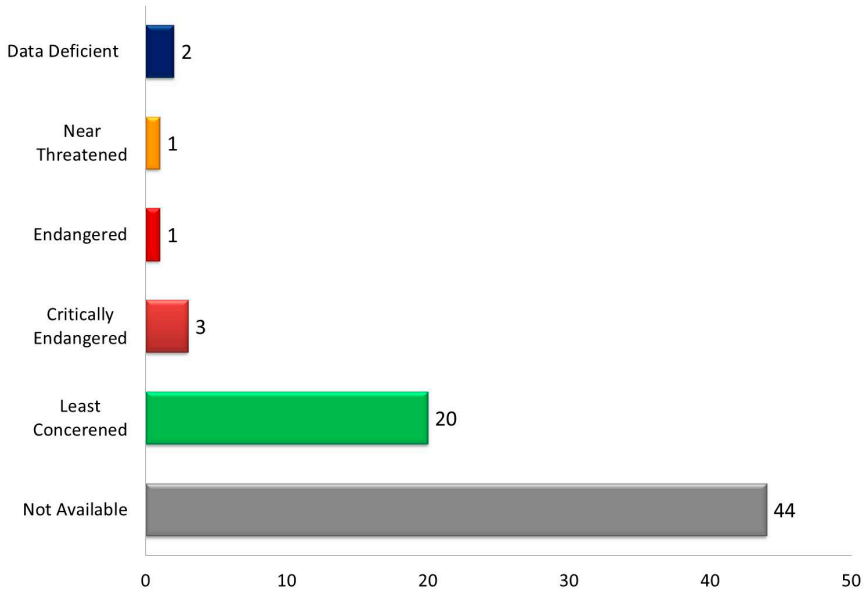

Figure 9. IUCN Red List Status of the Reported Medicinal Plant Species

Observed ethnobotanical data showed all identified species' uses frequencies were varied, some were utilized to a great extent while others in very low. For instances, the Relative Frequency of Citation (RFC) and Fidelity Level (FL) values of above five concerned species indicate that *Aegle marmelos* (Near Threatened, RFC 0.75 and FL 48%) and *Commiphora wightii* (Arn.) Bhandar (Critically Endangered RFC 0.58 FL 65%) both species were used significantly by the Van Gujjar tribe in the Study area. Albeit other concerned species *Chlorophytum borivilianum* Santapau & R.R.Fern. (Critinally Endangered) RFC 0.24 FL 20%, *Nardostachys jatamansi* (D.Don) DC. (Critinally Endangered RFC 0.12 FL 14% *Aconitum heterophyllum* Wall. ex Royle (Endangered RFC FL 0.08 17%) were less employed in the study area. Yet, all five concerned species' wild habitat under threat in the study area. The rest of the least concerned species showed fluctuating RFC and FL values, table 2.

Recent studies indicate that the Himalayan forest system is the world's most sensitive and threatened ecosystem. Excessed Anthropogenic interference including grazing, deforestation, rising human populations, socio-economic transformations, and over-exploitation of forest resources may be responsible for biodiversity as well as the loss of herbaceous plant species (Altaf *et al.* 2022). Undoubtedly, the Indian Himalayan system represents an enriched

biodiversity but a threatening ecosystem as well. The Himalayan tribes such as Gaddis, Pangwals, Kinnauris, Lahaulis, Bhots, and Gujjars in association with biodiversity cannot be overlooked (Prakash et al 2022).

In the study area, DHSB Van Gujjar tribe basically relied on local flora for health care, food, and fodder. Their traditional knowledge of medicinal plant uses was excellent. However, they were not much aware of the critically endangered species' status. But they take care of the medicinal plant species' natural habitat for future and emergency uses and further share such herbalism practices with their offspring. Therefore, for sustainable utilization of medicinal herbs, the role of local tribes is important, but unscientific overexploitation and ecosystem-influencing anthropogenic activities are necessary to be monitored and checked. Especially where locals depend on naturally occurring herbs for their health and other needs. Moreover, the current medicinal plant data could be helpful to promote medicinal plant cultivation in DHSB, which will improve conservation as well as the local livelihood of locals.

It is noticeable that the world's substantial population (up to 85 %) still relies on plant-based healthcare products. Herbal product demand has increased gradually; It was estimated at $83 billion USD previously (Yadav et al. 2015, Palhares et al, 2015).

Overall, the procured outcomes from the present study could be helpful for the sustainable utilization of herbal medicine and to fill the previous potential gaps like less understood ethnomedicinal knowledge of Van Gujjar and less documented medicinal flora in the DHSB area. In addition, the present result may enhance the scientific understanding of traditional medicine and its significance in herbal drug discovery.

Conclusion

Reported 71 traditional medicinal plants of 67 genera and 41 families in the study area DHSB Himalayan system enriched the previous ethnobotanical data and the results confirm that plant family such as *Fabaceae* and *Apocynaceae* were dominant in the area. Quantitative measures showed *Zingiber officinale*, *Azadirachta indica* A. Juss, and *Ageratum conyzoides* L. were among the most utilized plant species by the Van Gujjar tribe. However, the highest FL% (96%) was reported for *Z. officinale*. Similarly, the highest ICF value is 0.98, which shares dental & gum problems, digestive disorders, and wounds dominant diseases categories. The IUCN red list status of the threatened plant species status of 71 reported medicinal plant species indicated 28.1 % of plant species were least concerned, 4.2 % were critically endangered, 1.4 % were near threatened, 2.8 % were data deficient, 1.4 % were endangered and remaining 61.9 % species IUCN status were unknown as not available in IUCN database during our search. Critically endangered species *Chlorophytum borivilianum*, *Commiphora wightii*, and *Nardostachys jatamansi* utilization in the study area was limited. In addition, the Van Gujjar tribe also protects medicinal plant species for future and emergency uses, but still, the conservation of the regional flora cannot be overlooked due to anthropogenic disturbance and the critical Himalayan ecosystem. Therefore, more extensive quantitative and conservation ethnobotanical studies in the Himalayan Shivalik hills are suggested, especially to provide insight into local flora conservation and potential overexploitation.

Declarations

List of abbreviations: DHSB (Delhi-Dehradun Higway Shivalik hills Belt), **IUCN (**International Union for Conservation of Nature), **RFC (**Relative Frequency of Citation) **FL (**Fidelity Level) **Nt (**Number of Species), **Nur** (Number of Use Reports), **NA** (Not Available), **LC** (Least Concern), **CR** (Critically Endangered), **EN** (Endangered), **NT** (Near Threatened), **FL** (Fedility Level),**ICF** (Informant Consensus Factor),**RFC** (Relative Frequency of Citation), **POWO** (Plant of the World Online), **IPNI** (International Plant Names Index)**.**

Ethics approval and consent to participate:

This study did not involve any export animal or plants material. Information was obtained from the participants.

Consent for publication: Oral permission from participants and local authorities has been taken.

Availability of data and materials: Plant Samples (herbarium) were submitted in Company's Garden, Saharanpur, Uttar Pradesh; rest details available in this manuscript.

Competing interests: The authors declare no competing interests.

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Authors' contributions: Author NG Conceptualized and design the study, writing, pictures and sample collection. NG and VY Field work, survey, samples, data structuring, processing, manuscript writing, editing. Ashok Kumar Agrawal: Supervision, guidance, institutional support. Virendra Kumar Yadav: Proof reading and editing; RKS and RKJ essential editing and further proof reading.

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Literature Cited

Altaf A, Haq SM, Shabnum N, Jan HA. 2022. Comparative assessment of phyto diversity in Tangmarg Forest division in Kashmir Himalaya, India. Acta Ecologica Sinica 42(6):609-615.

Bahukhandi KD, Uniyal T, Ahuja NJ.2018. Biodiversity and Conservation of Medicinally Important Plants by Cultivation Method of Shivalik Hills of Sahaspur Block, Dehradun, Uttarakhand. In: Siddiqui N, Tauseef S, Bansal K. (eds). Advances in Health and Environment Safety. Springer Transactions in Civil and Environmental Engineering, Springer, Singapore, Pp. 127-132.

Balkrishna A, Gupta N, Gond DK, Sharma IP, Bhandari R, Arya V.2022. Survey of Indigenous Knowledge of Medicinal Plants in India. In: Goyal MR, Birwal P, Mishra S K. (Eds). Phytochemicals and Medicinal Plants in Food Design. Apple Academic Press, United States, Pp. 103-121.

Ekor M. (2014). The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety. Frontiers in pharmacology 4: 177.

Gaur RD.1999. Flora of the district Garhwal North West Himalaya (with ethnobotanical notes). Transmedia publications, Srinagar, India.

Gooch P. 2004. Van Gujjar: The persistent forest pastoralists. Nomadic Peoples 8(2):125-135.

Gupta SC, Prasad S, Tyagi AK, Kunnumakkara AB, Aggarwal BB. 2017. Neem (*Azadirachta indica*): An Indian traditional panacea with modern molecular basis. Phytomedicine 34: 14-20.

Gurme ST, Patil DN, Jadhav SV, Ahire ML, Mundada PS. 2022. *Azadirachta indica* (Neem) and *Berberis aristata* (Indian Barberry). In: Husen A. (Ed). Herbs, Shrubs, and Trees of Potential Medicinal Benefits. CRC Press, Boca Raton, Florida, United States, Pp. 365-376.

Heinrich M, Ankli A, Frei B, Weimann C, Sticher O. 1998. Medicinal plants in Mexico: Healers' consensus and cultural importance. Social Science & Medicine 47(11):1859-1871.

Hong DY. 2015. Flora of Pan-Himalaya. Science Press, Beijing, China.

IPNI.International Plant Names Index. 2022. Database. https://www.ipni.org/ (Accessed 17/06/ 2022)

IUCN Red list.The IUCN Red List of Threatened Species. 2022. Database. https://www.iucnredlist.org/(Accessed 17/06/ 2022)

Jadid N, Kurniawan E, Himayani CES, Andriyani, Prasetyowati I, Purwani KI, Muslihatin W, Tjahjaningrum ITD. 2020. An ethnobotanical study of medicinal plants used by the Tengger tribe in Ngadisari village, Indonesia. Plos ONE 15(7):e0235886

Kumar A, Kumar S, Komal, Ramchiary N, Singh P. 2021. Role of Traditional Ethnobotanical Knowledge and Indigenous Communities in Achieving Sustainable Development Goals. Sustainability 13(6):3062.

Kumar G, Chander H. 2018. Indigenous ethno-medicinal and ethno-veterinary practices in shivalik hills zone of Himachal Pradesh, India. Asian Journal of Advanced Basic Sciences 6(2):1-14.

Mahapatra A, Bhowmik P, Banerjee A, Das A, Ojha D, Chattopadhyay D. 2018. Ethnomedicinal Wisdom : An Approach for Antiviral Drug Development. In: Khan MSA, Ahmad I, Chattopadhyay D. (eds). New Look to Phytomedicine. Academic Press, Elsevier Inc, United States, Pp. 35-61.

Mao Q-Q, Xu X-Y, Cao S-Y, Gan R-Y, Corke H, Beta T, Li H-B. 2019. Bioactive Compounds and Bioactivities of Ginger (Zingiber officinale Roscoe). Foods 8(6):185.

Mbaveng A, Kuete V. (2017). *Zingiber officinale*. Kuete V.(Ed). Medicinal Spices and Vegetables from Africa: Therapeutic Potential Against Metabolic, Inflammatory, Infectious and Systemic Diseases. Academic Press, Elsevier Inc, United States, Pp. 627-639.

Morakinyo AO, Adeniyi OS, Arikawe AP.2008. Effects of *Zingiber officinale* on reproductive functions in the male rat. African Journal of Biomedical Research 11:329-334.

Nath V, Khatri, PK. 2010. Traditional knowledge on ethno-medicinal uses prevailing in tribal pockets of Chhindwara and Betul Districts, Madhya Pradesh, India. African Journal of Pharmacy and Pharmacology 4(9):662-670.

Palhares RM, Gonçalves Drummond M, dos Santos Alves Figueiredo Brasil B, Pereira Cosenza G, das Graças Lins Brandão M, Oliveira G. 2015. Medicinal plants recommended by the world health organization: DNA barcode identification associated with chemical analyses guarantees their quality. Plos ONE 10(5):e0127866.

Pintong A-r, Ampawong S, Komalamisra N, Sriwichai P, Popruk S, Ruangsittichai J. 2020. Insecticidal and Histopathological Effects of *Ageratum conyzoides* Weed Extracts against Dengue Vector, *Aedes aegypti*. Insects 11(4):224.

Radha Prakash S, Sharma N, Kumar A, Kumari N, Puri S, Pundir A, Kumar V, Sharma AK, Rais N, Dey A, Lorenzo JM, Mekhemar M, Kumar M. 2022. A survey on ethnoveterinary medicines used by the tribal migratory shepherds of Northwestern Himalaya. Journal of Ethnopharmacology 296:115467.

Ramakrishnan R. 2013. Anticancer properties of *Zingiber officinale* – Ginger: A review. International Journal of Medicine and Pharmaceutical Sciences 3(5):11-20.

Rana SK, Rawat GS. 2017. Database of Himalayan Plants Based on Published Floras during a Century. Data 2(4):36.

Royal Botanic Gardens Kew. Plant of the World Online. 2022.Database. https://powo.science.kew.org/ (Accessed 17/06/ 2022)

Sharma J, Gairola, S, Gaur RD, Painuli, RM. 2012. Forest utilization patterns and socio-economic status of the Van Gujjar tribe in sub-Himalayan tracts of Uttarakhand, India. Forestry Studies in China 14:36-46.

Sharma UD, Kumar S, Sharma K, Datt S. 2015. Diversity of Medicinal Flora of Lower Shiwalik Hills of the Western Himalaya, India. International Journal of Advanced Research 3(10):905-910.

Srithi K, Balslev H, Wangpakapattanawong P, Srisanga P, Trisonthi C. 2009. Medicinal plant knowledge and its erosion among the Mien (Yao) in northern Thailand. Journal of Ethnopharmacology 123(2):335-42.

Tardío J, Pardo-de-Santayana M. 2008. Cultural Importance Indices: A Comparative Analysis Based on the Useful Wild Plants of Southern Cantabria (Northern Spain). Economic Botany 62:24-39

Yadav N, Ganie SA, Singh B, Chhillar AK, Yadav SS. 2019. Phytochemical constituents and ethnopharmacological properties of *Ageratum conyzoides* L. Phytotherapy Research 33(9):2163-2178.

Yadav RP, Panwar P, Arya SL, Mishra PK. 2015. Revisit of Shivalik region in different states of northwestern India. Journal of the Geological Society of India 86:351-360.