Indian Journal of Traditional Knowledge
Vol 24(6), June 2025, pp 555-565
DOI: 10.56042/ijtk.v24i6.10529

Factors determining ethnomedicinal plants choice in Pushparajgargh Tehsil of Madhya Pradesh, India

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Received 18 April 2024; revised 10 May 2025; accepted 02 June 2025

The quantitative ethnobotanical indices and the important value index (IVI) were used to analyze the socio-cultural and ecological significances of the ethnomedicinal flora of a tribal-dominated division of the district Anuppur (Madhya Pradesh), India. The documented plants treat various ailments caused by taxonomically unrelated pathogens. The Informant Consensus Factor (ICF) results showed that reported plants were used to treat 12 different categories of diseases, including alcoholism. Plants such as *Hedychium coronarium, Andrographis paniculata, Shorea robusta, Acorus calamus,* and *Azadirachita indica* were the most important and popular plants among the local healers. The Index of Cultural Significance and IVI values further confirm plants' cultural and ecological importance. Findings also underpin demography (*i.e.*, versatility and availability), social dynamics, and human traits (age, dynamics of knowledge, and social network) as reasons for the selection of plants by the healers.

Keywords: Ethnobotanical hypotheses, Ethnomedicinal plants, Local and traditional healers, Quantitative ethnobotanical indices, Tribes

IPC Code: Int Cl.[25]: A61K 36/00

Traditional indigenous knowledge is a network of knowledge (factual data), beliefs (religious concepts), and traditions (practices) put into preserving, communicating, and contextualizing indigenous relationships with culture and landscape over time[1]. Plants have played a major role in shaping human societies, including curing various ailments of human and domesticated animals[2].

The study of local/regional plants and their human uses through the traditional knowledge of the people and culture of the area is known as ethnobotany. Most ethnobotanical studies involve an acontextual listing of plants according to their uses by a set of populations[3]. This approach has invited serious criticism of ethnobotany as a ‘week’ or ‘pseudoscience’[4]. Kroeber[5] was the first to argue in favor of quantitative ethnobotany, which is an application of quantitative techniques for analyzing contemporary plant use data. Since the mid-1980s, the subsequent use of quantitative ethnobotanical indices and statistical tools borrowed mainly from ecology provided valuable information about plants' socioeconomic and cultural importance[6,7]. Reyes-García *et al.*[8] opined that quantitative data is complementary to qualitative data. However, quantitative data have rarely been used to explain the reason and rationale of select plants’s use by the people for a wide range of uses. This has resulted in a growing demand for theory-inspired and hypothesis-driven research in ethnobotany to improve the rigor of the discipline[3].

Further, traditional knowledge provides valuable information and insights that help explain and contextualize scientific data. The main aim of ethnobotany is to establish plants' economic and cultural values and document traditional knowledge of their use. Nonetheless, ethnobotanical studies are crucial for bioprospection and drug discovery programs, especially in the wake of new and emerging infectious diseases, the rising cost of existing drugs, and the development of resistance in pathogens against available drugs, a task assigned to pharmacologists. According to the World Health Organization, approximately 80% of the global population, especially ethnic and tribal communities, rely heavily on plant/natural resources for primary

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healthcare[2]. Proper documentation and validation of traditional medicinal knowledge and traditions and their integration into a country's primary public healthcare structure is needed to reinforce the confidence of young herbalists in their knowledge systems, who are otherwise moving gradually away from their traditions due to confusion and lack of opportunity[2].

In our previous studies conducted in a tribal-dominated region of the district Anuppur, Madhya Pradesh, India, we showed that local communities and traditional healers of the area possess valuable indigenous/traditional knowledge about the local plant resources and their use to treat ailments/diseases prevalent in the area, particularly malaria, which is very common in the areas[9,10]. Here, we used a set of quantitative ethnobotanical indices to ascertain the socio-economic and cultural importance of the selected plants for different medicinal uses, notably to treat malaria. More importantly, we used the results of quantitative analyses to explain their reason for the choice.

Materials and Methods

Study area

District Anuppur is located in the eastern corner of the Indian state of Madhya Pradesh, and has been divided into four administrative divisions (*i.e.*, tehsil): Pushparajgarh, Anuppur, Jaithari, and Kotma. Our study area, Pushparajgarh, is the largest division of the district with 96% rural population, residing in 251 villages and 119 panchayats. The climate of the region is characterized by hot summer (March-June; average May temperature 40ºC), monsoon seasons (July-October), and cool autumn seasons (November-February (www.nic.in), receiving an annual rainfall of 120 cm, with summer temperatures ranging from 28-46ºC, and average winter temperatures around 15ºC. Most of the area is hilly and covered with moist-deciduous forests (Fig. 1), dominated by the Sal tree (*Shorea robusta*), and harbors a great diversity of medicinal plants. A bulk of its total population (nearly 77%) belongs to scheduled tribes (www.anuppur.nic.in), residing mainly in highly

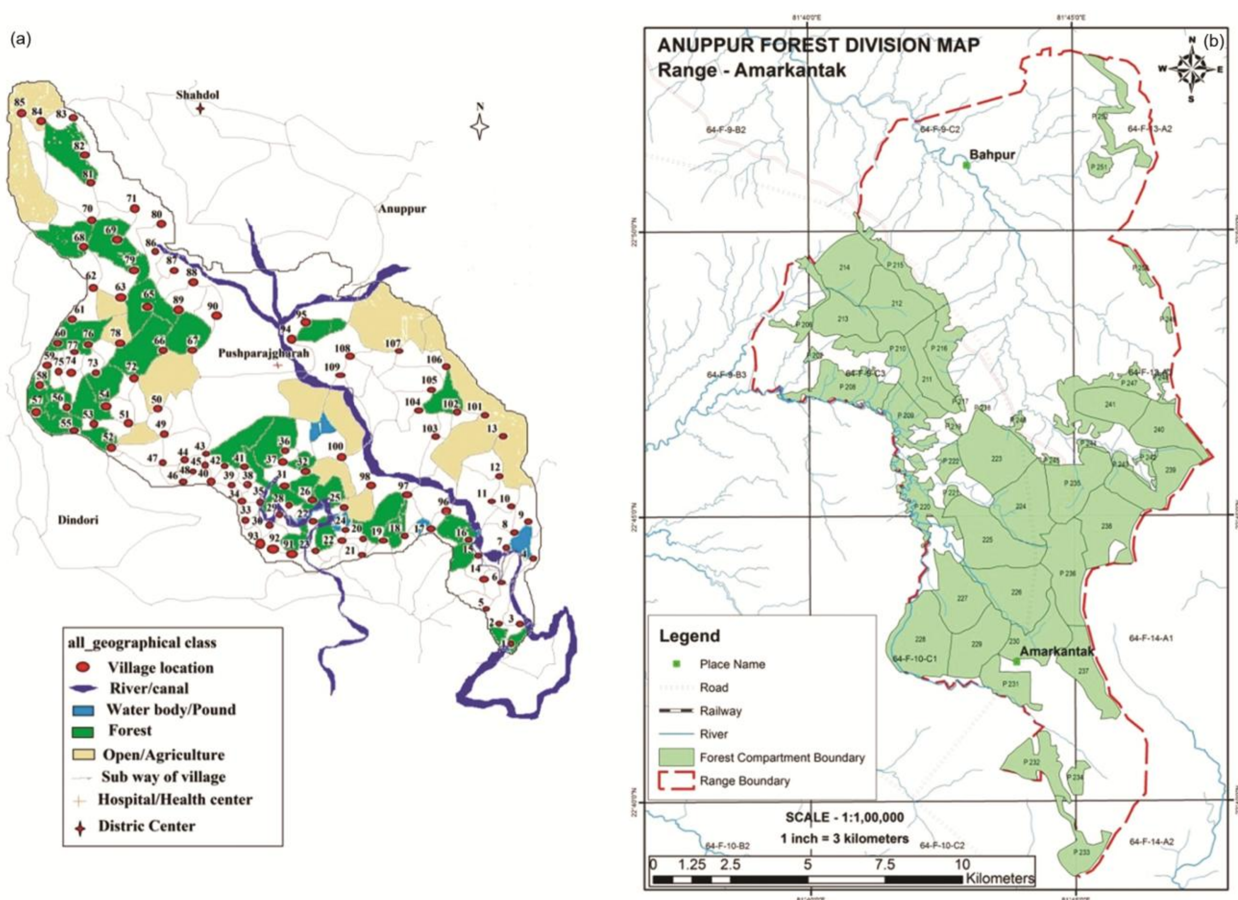

Fig. 1 — Geographical (upper) and vegetation (lower) maps of the study area (Pushparajgarh Tehsil) showing high forest cover (Source: Author)

remote and isolated villages, abound with natural resources and indigenous lifestyles. The tribal population of the area survives primarily on agriculture. The area experiences a high degree of vector-borne communicable diseases, particularly different forms of malaria. Common preventive practices include using insecticide-treated bed nets and periodic destruction of mosquito breeding and resting areas. There are four primary health centers, 15 sub-health centers, and one community health center in the tehsil. The remote rural parts of the tehsil lack -advanced medical facilities. And, because of deep cultural roots the area has plenty of traditional/folk healers, locally known as - *Guniya, Baidya, Hakim, Sokha,* etc., In their treatment, they rely heavily on the availability of local flora and fauna.

Survey, identification, and documentation of medicinal plants

The fieldwork was conducted from July 2016 to July 2019 in the 109 villages of the area, based on the presence of traditional healers in the village. Before conducting the study, permission was sought from the University Ethical Committee (Reference no. IGNTU/IEC/2015/11 dt 03 November 2015). The study team of five people visited the identified villages and interacted with healers. The 'Snowball method' was used to search the key informants. A participatory observation approach was used to record the information, using targeted semi-structured questionnaires (SSQ) and schedules (two questionnaires with overlapping questions to ensure consistency in response). Since many respondents were illiterate, face-to-face interviews (semi-structured interviews, SSI) were also conducted (for details, refer to Dwivedi *et al*.[9] and references therein). A total of 25 people were interviewed. The necessary approval to conduct the study was obtained from the NRDMS (the funding agency), and authorization and consent from the respective community leaders and village elders. The participants were informed about the nature, benefits, and potential risks involved in the study. Suitable literature and floras were used to identify the plant specimens, and voucher specimens were deposited at the Herbarium of the Department of Botany, Indira Gandhi National Tribal University, Amarkantak. The findings on the diversity, distribution, and use of medicinal plants, particularly anti-malarial plants, by the local healers have already been published[9,10]. A hand-held GPS (Montana 680; Germin™) was used to record the Global Positioning System (GPS) coordinates in the study area. The scattered plot and radar diagram were drawn in Microsoft Excel.

Quantitative assessment of the ecological and ethnobotanical importance of the reported medicinal plants

We used quantitative ethnobotanical indices such as - Important Value Index (IVI), Use Value (UV), Relative Frequency of Citation (RFC), Fidelity Level (FL), Relative Popularity Level (RPL), Rank Order Priority (ROP), Informant Consensus Factor (ICF) and Index of Cultural Significance (ICS), to ascertain the ecological and ethnographic importance of the reported plants,

Importance value index (*IVI*)

It provides information about a species' ecological importance (species dominance) in a plant community. Species density, frequency, and abundance are used to calculate it. The IVI is a sensitive indicator of anthropogenic activities. We have calculated the IVI value for trees and shrubs only.

$$\text{IVI} = \text{Relative frequency} + \text{Relative density} + \text{Relative abundance}$$

To measure the frequency, density, and dominance, the quadrate (plots) method was used. The quadrat size used for trees was 20 m X 20 m, while it was 5 m X 5 m (25 sq. m) for shrubs. The standard species-area curve (considering approximately 1% of the total area) was used to decide the number of quadrats to be used. Habitus (*i.e.*, growth form) of the species were designated on the developmental stage of members of the species - seedlings (height up to 20 cm), saplings and shrubs (height > 20 cm but DBH < 10 cm), small trees (DBH ≥ 10 cm but height < 30 cm), and big trees (DBH ≥ 30 cm)[11]. The following equations[12,13] were used to calculate the relative frequency, density, and abundance:

$$\text{Frequency} = \frac{\text{Total number of quadrats in which the species has occured}}{\text{Total number of quadrats studied}} \text{ x } 100$$

(to extrapolate the results for the entire area, per quadrat above mean/average number of individuals of a species was multiplied by the mean number by the number of quadrats required to sample the one-hectare area)

$$\text{Abundance} = \frac{\text{Total number of individuals of the species in all the quadrats}}{\text{Toal number of quadrates in which the species occured}}$$

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Sum of frequency of all the species}} \times 100$$

$$\text{Relative density} = \frac{\text{Density of a species}}{\text{Sum of density of all the species}} \times 100$$

$$\text{Relative abundance} = \frac{\text{Abundance of individual species}}{\text{Total abundance of all the species}} \times 100$$

Distribution pattern

To find the distribution pattern of species, which indicates the rate of species richness during the sampling, the ratio of abundance to frequency (A/F) was used[14]. If A/F value is < 0.025 the distribution is regular, random for > 0.025 but < 0.05, and contagious for > 0.05[12]. The rate at which a new species is encountered with increasing sample size affects the distribution pattern. It reduced as the distribution of species changes from being random to progressively patchier[15]. Increasing patchiness suggested that more species will be encountered in one sample only. The observational data from a community was used to verify the results based on a whole-of-community viewpoint[7].

Use value (*UV*)

This was used to determine the relative importance of an indigenous plant species, and calculated as follows:

$$UVs = \sum Ui/n$$

Here 'Ui' is the sum of the total number of use citations by all informants for a given species, and 'n' is the total number of informants[16].

Relative frequency of citation (*RFC*)

The RCF shows the local importance of each species, calculated using the frequency of citation (FC, the number of informants mentioning the use of the species) divided by the total number of informants participating in the survey (N), without considering the use-categories[17]:

$$RFC_s = \frac{FC_s}{N} = \frac{\sum_{i=i_1}^{i_N} UR_i}{N}$$

Fidelity level (*FL*)

FL is the percentage of healers who described the uses of specific plant species to treat a particular ailment in the study area. The FL was calculated as per Friedman *et al*[18]:

$$FL\,(\%) = (NP/N)\ X\ 100$$

Here, NP denotes the number of healers reported the use of a particular plant species for treating a particular disease; and N is the total number of healers citing the use of plant species for any treatment.

Relative popularity level (*RPL*)

RPL is the ratio of diseases treated by a particular plant species and the total number of contacted healers. RPL value 1 indicates that the plant is well accepted, while a value less than 1 suggests less accepted plant species[18].

Rank order priority (*ROP*)

ROP is a correction factor used to appropriately rank the surveyed medicinal plants with different FL and RPL values. For a species, it is a function of FL value and RPL[18].

$$ROP = FL\ X\ RPL$$

Informant consensus factor (*ICF*)

ICF indicates the informant's consent to medicinal use of the plant. It analyzes the inconsistency in plants utilization against various ailments, and calculated as per Trotter & Logan[19].

$$ICF = Nur - Nt/\ Nur - 1$$

Here, Nur is the total number of use reports for each disease category, and Nt is the number of species used in a particular category. A plant species with ICF value close to 1 is highly popular among the traditional healers. A lower ICF value is indicative of random use of plants for treating a particular ailment.

Index of cultural significance (*ICS*)

ICS value was calculated using the quality of use, the intensity of use, and the exclusivity[20].

$$\sum_{i=1}^{n} (q \times i \times e)\ ni$$

Since each species has several uses, the formula becomes as below -

$$ICS = (q_1 \times i_1 \times e_1)n_1 + (q_2 \times i_2 \times e_2)n_2 \ldots\ldots\ldots + (q_n \times i_n \times e_n)n_n$$

Here, ICS is the sum of individual "use" values from 1 to 'n' (*i.e.*, the last use described); the subscript 'i' represents the value 1 through n, consecutively; q = quality value, i = intensity value, e = exclusivity value.

Statistical analyses

The non-metric multidimensional scaling (nMDS) was used as an ordination method for finding clusters of species and respondents' characteristics such as - gender, educational status, age group, social group, and practicing experience (in years). The frequency data of reporting a species makes the data an abundance data. The Brey-Curtis's distance is used as a distance measure for ordination. The data was analyzed using the Vegan package and R software version 4.4.2.

Results and Discussion

A total of 269 healers participated in the study, 230 (85.5%) were male and 39 (14.5%) were females. Nearly 96% (259) of the total respondents were from different tribal group smainly - *Gond* (37.5%), *Panika* (22.7%), *Baiga* (21.2%), and *Bheel* (14.9%). Age-wise, 16% of the total healers were aged between 41-50 years, 30% between 51-60 years, 27% between 61-70 years, 24% between 71-80 years, and 3% were above the age of 81. Most respondents (55%) possess more than two decades (*i.e.*, 21-40 years) of experience using plants to treat malaria. A majority of the healers (67.2%) were either illiterate or had only a primary level of education (Table 1).

Out of the 25 traditional healers, 17 were well-known herbalists of the region and were self-employed. Others are involved in farming, shop keeping, and iron molding for livelihood. A majority of male healers (89.6%) showed a culture of kinship *i.e.*, transferring their traditional knowledge of disease identification and treatment through male lineage only. Elderly people (50-70 years) possess greater knowledge of medicinal plants.

A total of 78 plant species belonging to 67 genera and 46 families were documented in the studies as being traditionally used in the area as medicinal plants[9,10] (Supplementary Table S1). The distribution of medicinal plants in the study area was centered around 505 to 1048 meters above sea level (masl); between 22°41'09.27" to 22°59'91.33" latitudes (with maximal diversity reported around 22º44') and between 81°13'99.70" to 81°45'65.65" longitude (with maximal distribution around 81°44' longitudes). Figure 2 presents the coordinate-wise radar layout of the distribution of medicinal plants in the studied area. Figure 2b is a scattered plot of longitudinal and latitudinal distributions of the medicinal plants in the area. The majority of the medicinal plants were growing in forest areas (42%), followed by the roadside (23%). Nearly 10% of plants were present in the entire study area, while 11% were under cultivation. Habit-wise, the majority of plants are herbs (49%), followed by shrubs (22%) and trees (15%)[9,10].

Table 1 — Demographic profile of the respondents (after Dwivedi *et al*[9]).

Variable	Category	Number
Informant category	Traditional healers	25
	Indigenous healers	244
Professional experience of the healers	5-20 years	09
	21-40 years	16
	Above 40	40
Gender	a. Female	
	Traditional tribal healers	04
	Indigenous people	35
	b. Male	
	Traditional tribal healer	21
	Indigenous people	209
Age of the respondents	Up to 40 years	80
	41-60 years	103
	61-70 years	62
	71-80 years or above	24
The main occupation of the respondents	Traditional health practitioner	17
	Peasants	146
	Blacksmiths	11
	Shepherds	09
	Shop keepers	15
	Housewives	22
	Students	49
Literacy level	Illiterates	69
	Primary education	112
	Secondary education	64
	Graduate	24
Tribal/Sub tribal communities	Gond	101
	Baiga	57
	Panika	61
	Bheel	40
	Others	10

The study area experiences a high prevalence of malaria, particularly in tribal-dominated areas, which shows seasonality and is governed by mosquitogenic factors, their transmission, and the socio-demographic status of the population[21]. Local healers were using 19 plants to treat malaria[9,10] (Supplementary Table S2), growing mainly in wild habitats such as forest areas (57.89%), roadside (15.78%), and wasteland (10.52%). Approximately 15.78% (e.g., *Azadirachta indica*, *Ocimum tenuiflorum*, and *Vitex negundo*) were grown at places suitable for cultivators (*i.e.*, home gardens). The maximal Anti-Malarial Index (AMI) value of 0.338 was recorded for *Andrographis paniculata*, which means 91 out of 269 informants have suggested or used the plant alone or in synergy with other plants to treat malaria[9].

Quantitative analyses of the ethnobotanical importance of medicinal plants in the area

Informant consensus factor (*ICF*)

The ICF value (ranging from 0 to 0.46) suggests that reported plants are used to treat 11 broad categories of diseases - gastrointestinal disorders (25%), fever (12.86%), dermatological (12.14%), respiratory (10%), skeletomuscular problems (7.86%), blood/genetic disorders (7.14%), eye, nose, ear, mouth diseases (5%), urinogenital disorders (5%) body energizers (4.29%), nervous disorders (1.43%) and cardio-vascular disorders (0.71%), respectively (Table 2). Besides, some are also being used to treat alcoholism, snake bites, dog bites, and insect repellents (Supplementary Table S1). Based on the opinion of 25 traditional healers and from bioprospection (say pharmacological) viewpoints, we calculated the UV, RCF, FL, RPL, and ROP values for 18 potential plants (Table 3).

The calculated UV value ranged from 0.06 to 0.88, with the highest value reported for *Hedychium coronarium* (0.88), followed by *A. paniculata* (0.75) and *Diospyros melanoxylon* (0.50). The RFC value ranged from 0.19 to 0.76. The maximum RCF value was recorded for *Hedychium coronarium* and *A. paniculata* (0.77) (Table 3).

The FL value ranged from 6.66 to 100%. A high FL value indicates the high prevalence of a disease in the study region and the use of a particular plant to treat that disease. *S. robusta* showed 100%, while

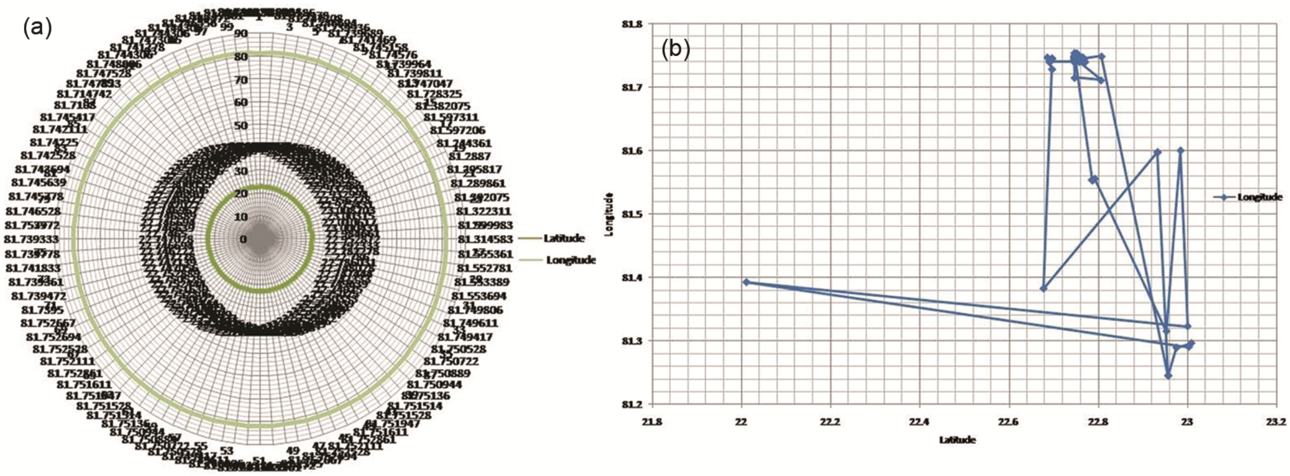

Fig. 2 — (a) Radar layout chart with GPS coordinates for the medicinal plants in the area, (b) Scattered GPS data chart showing medicinal plants in the area

Table 2 — Informant consensus factor (ICF) value of reported plants against various ailments

Sl. No.	Ailments	Biomedical terms	No. of use report	% of report	No. of use species	% of species	ICF
1	Fevers	Common fever, Malaria, Typhoid, Sunstroke	18	12.85	16	14.03	0.11
2	Dermatological disorders	Cut, Wounds, Boils, Skin rushes & itching, Ringworm, Ecto-parasites, Body Inflammation	17	12.14	14	12.28	0.18
3	Respiratory diseases	Cold, Cough, Asthma, Tuberculosis	14	10	8	7.01	0.46
4	Gastro-intestinal disorders	Diarrhea, Dysentery, Nausea, Indigestion, Vomiting, Stomach-ache, Piles, Jaundice	35	25	24	21.05	0.32
5	Ureno-genital problems	Sexual debility, Infertility, Menstrual disorders, Frequent urination, Spermatorrhoea	7	5	6	5.26	0.16
6	Nervous disorder	Epilepsy (Fit), Memory loss	2	1.42	2	1.75	0
7	Skelto-muscular pain and swelling	Headache, Joint pain, Swelling, Body-ache, Muscular pain, Arthritis, Paralysis, Rheumatism	11	7.85	10	8.77	0.1
8	Cardio-vascular disorder	Cardiac, Blood pressure	1	0.71	1	0.87	0
9	Eye, nose, ear, and mouth problems	Ear & eye pain, Throat shore, Nose bleeding, Mouth ulcer, Tooth-ache	7	5	6	5.26	0.16
10	Body energizers	Rejuvenation, Lactation, Easy delivery, Stimulant, Fat-reducer	6	4.28	6	5.26	0
11	Blood/genetic disorders	Sickle cell anemia, Blood deficiency, Cancer, Diabetes	10	7.14	10	8.77	0
12	Other	Alcoholism, Snakebite, Dog bite, Insect repellent	12	8.57	11	9.64	0.09

Martynia annua with 6.66% FL. The RPL value ranges from 0-1, where '1' indicates the total popularity of the plants in disease treatment, whereas '0' means no use of the plant to treat any ailment. The high value showed the species' popularity and high efficacy among local traditional healers. The recorded RPL values ranged between 0.25 for *Cordia macleodii* to 1.0 for *H. coronarium* and *A. paniculata* (Table 3).

The ROP is used to rank plant species using FL values. Amongst 18 plant species, only six plants had ROP values above 50. The minimum value was recorded for *M. annua i.e.,* 05. Table 4 shows that nine of 18 plants are the most important for people in the area namely, *H. coronarium, Tinospora cordifolia, S. robusta, Ocimum sanctum, A. paniculata, Cordia macleodii, Diospyros melanoxylon, Terminalia chebula* and *Curcuma caesia*. *Parthenium hysterophorus* is an alien species with no cultural significance (has minimum ICS value) for the local people. It was reported by a single young respondent (35 years) who was unaware of its alien-invasive nature. Therefore, his narration may be treated as factual ignorance.

Based on their frequency (%), density (individuals/ hectare), and abundance (individuals/sample), we selected some of the tree and shrub species to analyze their ecological importance. The results showed that *S. robusta* (90%), *Desmodium oojeinensis* (85%) and *D. melanoxylon* and *Buchanania lanzan* had the maximal frequency (75%), Followed by *A. indica* (60%), *Gmelina arborea* (50%), *Cissampelos pariera, T. chebula* and *T. bellirica* (40%). Amongst shrubs, the maximal frequency was recorded for *Parthenium hysterophorus* (75%) and *Calotropis procera* (60%).

S. robusta (246) showed the maximal density, followed by *D. oojeinensis* (81) and *B. lanzan* (69) (showed uniform distribution across the sites). *D. melanoxylon* (52), *A. indica* (41), *G. arborea* (33), *C. pariera* (29), *T. chebula* (26) and *T. bellirica* (23) showed high frequency but not density. In shrubs, *P. hysterophorus* showed maximal density (432) in plains and lower hilly areas, while *C. procera* showed maximal density (134) in non-hilly areas. *S. robusta* had the highest abundance (*i.e.,* individual per sample area) (28.5); followed by *D. oojeinensis* (6.8), *B. lanzan* (4.3), *D. melanoxylon* (4.3), *A. indica* (3.2), *G. arborea* (3.1), *C. pariera,* (2.7) *T. chebula* and *T. bellirica* (2.4). In shrubs, *P. hysterophorus* had the maximal abundance (35.4), followed by *C. procera* (11.2). The IVI value suggests that *S. robusta* (a tree) and *P. hysterophorus* (a shrub) are the dominant species in the study area**.** Likewise, distribution pattern data suggests that almost all species show contagious distribution (Table 5).

Table 3 — UV, RFC, FL, RPL, and ROP values of some of the widely used and pharmacologically important plants recorded during the study.

Sl. No	*Botanical Name*	UV	RFC	FL	RPL	ROP
1	*Acorus calamus*	0.26	0.57	80.00	0.75	60
2	*Andrographis paniculata*	0.75	0.77	40.00	1.00	40
3	*Azadirachita indica*	0.21	0.73	84.20	0.95	80
4	*Cissampelos pariera*	0.45	0.42	81.80	0.55	45
5	*Cordia macleodii*	0.40	0.19	80.00	0.25	20
6	*Diospyros melanoxylon* Roxb.	0.50	0.38	80.00	0.50	40
7	*Ficus religiosa*	0.30	0.38	80.00	0.50	40
8	*Hedychium coronarium*	0.88	0.77	40.00	1.00	40
9	*Martynia annua*	0.06	0.58	06.66	0.75	05
10	*Ocimum sanctum*	0.33	0.57	86.66	0.75	65
11	*Parthenium hysterophorus*	0.30	0.38	90.00	0.50	45
12	*Pyrus communis*	0.20	0.57	86.66	0.75	65
13	*Shorea robusta*	0.15	0.50	100.00	0.65	65
14	*Syzygiumcumin*	0.33	0.46	91.66	0.60	55
15	*Terminalia chebula*	0.16	0.23	83.33	0.30	25
15	*Tinospora cordifolia*	0.06	0.57	13.33	0.75	10
17	*Vernonia anthelmintica*	0.28	0.20	71.42	0.35	25
18	*Curcuma caesia* Roxb.	0.31	0.36	55.31	0.34	19

Table 4 — Index of cultural significance (ICS) value of the selected plants

Sl. No	*Botanical Name*	ICS value (%)
1	*Acorus calamus*	36.47
2	*Andrographis paniculata*	61.04
3	*Azadirachita indica*	37.35
4	*Cissampelos pariera*	38.36
5	*Cordia macleodii*	60,16
6	*Diospyros melanoxylon* Roxb.	46,48
7	*Ficus religiosa*	27.36
8	*Hedychium coronarium*	72.35
9	*Martynia annua*	27.26
10	*Ocimum sanctum*	66,48
11	*Parthenium hysterophorus*	02.36
12	*Pyrus communis*	27.36
13	*Shorea robusta*	67.26
14	*Syzygium cumin*	27.36
15	*Terminalia chebula*	55.36
15	*Tinospora cordifolia*	67.35
17	*Vernonia anthelmintica*	29.34
18	*Curcuma caesia* Roxb.	57.36
No.	Category: ICS values	Plant species
1	Most important (40- 100)	07
2	Important (20-39)	10
3	Less important (0-19)	01
4	Unimportant (0)	-
Total	18	

Table 5 — Phytosociological data of selected species

Sl. No.	Species	Density	Frequency (%)	Abundance	IVI	Distribution Pattern
1	*Azadirachita indica*	41	60	3.2	15.25	0.053
2	*Buchananialanzan*	69	75	4.3	19.82	0.057
3	*Calotropis procera*	134	75	35.4	26.44	0.472
4	*Cissampelos pariera*	29	40	2.7	10.84	0.068
5	*Desmodium oojeinensis*	81	85	6.8	25. 73	0.080
6	*Diospyros melanoxylon*	52	75	4.3	19.41	0.057
7	*Gmelina arborea*	33	50	3.1	13.02	0.062
8	*Parthenium hysterophorus*	432	60	11.2	56.46	0.186
9	*Shorea robusta*	246	90	28.5	61.44	0.316
10	*Terminalia bellirica*	23	40	2.4	10.05	0.060
11	*Terminalia chebula*	26	40	2.4	10.31	0.060

Traditional medicinal knowledge has been used for a long time to cure various human ailments. This has been well documented in Indian, Chinese, Egyptian, Roman, and other ancient and medieval cultures. In many of these societies - native, tribal, and sub-tribal populations are the dominant stakeholders of these knowledge systems and are considered the custodians of the associated knowledge and traditions. In many local and indigenous societies, and to a certain degree in advanced societies, people prefer traditional medicines over allopathic treatments[2]. Besides, the documentation of this knowledge of local, indigenous, and tribal people is vital to safeguard a country's valuable traditions and natural wealth. As well as strengthen the intellectual property rights of these people and communities.

We have surveyed the medicinal plants used by local people and traditional healers in a tribal-dominated Pushparajgargh division of the district Anuppur of Madhya Pradesh, using their traditional knowledge and GIS technique[9,10]. Since the area experiences a high load of different forms of malaria[21], we also documented the potential anti-malarial plants of the area. We characterized the anti-malarial potential of a few plants under *in vitro* conditions[22,23]. In the present study, we made a quantitative assessment to ascertain the socioeconomic, ecological, and cultural context of some of the plants.

The dominance of male healers (89.6%) reflects the prevalent patrilineal culture of kinship in the area. Since, elderly people (50-70 years) have spent much time treating the people and have been in direct contact with plant resources for a relatively long time, they possess better knowledge of medicinal plants. Because of uncertainty in business and exposure to modern education, young people have little interest in learning and practicing ethnomedicinal wisdom that would perpetuate indigenous knowledge[2]. Because of age, very old traditional healers (75-85 years) do not practice. We also observed that many healers were unwilling to disclose their knowledge, which is not a good sign, as this will lead to the loss of valuable information. Since this knowledge would help in the quick and proper identification of natural resources. Because of limited earnings through practice and a low literacy rate, many traditional healers have taken to other occupations such as – blacksmithing, shop keeping, etc.

The majority of the traditionally used plants are herbs and shrubs growing in nearby forests. Owing to their potency and fast regeneration, herbs have been widely used across the culture to treat various diseases[24]. The ICF data suggests that these plants are used to treat gastrointestinal (GIT) disorders, fever, dermatological, respiratory, skeletomuscular, blood/genetic disorders, eye, nose, ear, mouth diseases, urinogenital problems, body energizers, nervous disorders and cardio-vascular disorders, respectively. Besides, they were also used to treat alcoholism, snake bites, dog bites, etc. Since the study area is prone to different forms of malaria, traditional and folk healers use local plants (*i.e.*, 19 plants) and parts thereof to cure the disease.

Further, none of the reported medicinal or antimalarial plants is confined to a single region, except *H. coronarium* and *Curcuma caesia*, which were present only in Amarkantak. The rest were distributed throughout the study area. Maximum antimalarial plants were present in the Amarkantak region of the tehsil. The suitable climatic conditions and fewer anthropogenic disturbances due to the low population pressure support many of these plants growing in the wild, which is positively correlated with the number of traditional healers in the area. In Bhundakona, Harratola, Barati, Ponki, Kabir Chabutara, Babaghat, Jaleshwar, Kapildhara, Mohandi, and Khati medicinal and antimalarial plants had been growing nicely and distributed along the roadside, deep in the forest and in moist wastelands. The highest numbers of antimalarial plants were recorded between 722 to 752 mamsl. Herbs like *T. foliolosum* (823 m) were present at the highest altitude, while *J. adhatoda* (497 m) at the lowest altitude. Regarding shrubs, *D. metel* (803 m) was recorded from the highest elevation, while *V. negundo* (622 m) was from the lowest. Climbers such as *T. cordifolia* were present at the highest elevation (926 m) whereas *C. colocynthis* was at the lowest elevation (552 meters). Amongst trees, *H. antidysenterica* was present at the highest elevation (1048 m), while *A. indica* at the lowest (452 m)[10].

Quantitative ethnobotanical data establish the socio-cultural importance of these plants for local communities. Use value indicates the proportionate importance of species vis-à-vis documented plants[25]. Species of *H. coronarium* (0.88) showed maximal UV, followed by *A. paniculata* (0.75) and *D. melanoxylon* (0.50). The maximal RFC value (*i.e.*, the maximum number of citations by traditional healers), was recorded for *H. coronarium* and *A. paniculata* (0.77). The highest FL value of *S. robusta* (100%) suggests its use to treat a high prevalent disease in the study region. *M. annua* showed the minimum (6.66%) FL value. These findings highlight the authenticity of our data on the plant used for treating a particular ailment. The higher the FL value, the more authentic will be the information collected.

The RPL value of ʿ1ʾ indicates the total popularity and efficacy of a plant in disease treatment, whereas ʿ0ʾ means no use to treat any ailments. We found RPL values ranged between 0.25 (*C. macleodii*) and 1.0 (*H. coronarium* and *A. paniculata*). The RPL value becomes redundant when the average number of medicinal uses per plant does not increase with the increasing number of healers. A rank order priority above 50 shows the effectiveness or popularity of the plant species among the local people, but a lower value suggests a declining interest in traditional healers. The index of cultural significance (ICS)[20] data suggests that out of 18 plants considered, seven are most important while ten are important. This also shows the cultural importance of plants to the native population. Since *P. hysterophorus* is an alien species, its reported cultural insignificance is understandable.

The IVI values showed the ecological importance of some of these plants. Results show that species such as *S. robusta* (tree), *C. procera* (dominant species in the area), and *P. hysterophorus* (shrubs) have high IVI scores. Amongst these, *P. hysterophorus* is a notorious invasive species causing serious damage to the ecosystem. Visual observations suggest that the species has penetrated deep into the forests, which is a worrisome sign and bad for the native flora. The dominant species showed aggregated or clump distribution, preferring environments suitable for their growth, and are vital for the area's ecology.

The stress plot suggested a stress level for nmds to be 0.01, which is a good fit, indicating a good two-dimensional ordination (Fig. 3a & Fig. 3b). Species formed three relatively distinct clusters. Some species are far away from these clusters, which may be classified as outliers. Closely positioned characteristics (*i.e.*, male, indigenous people, educated, young, low experience; traditional healers, illiterate, old, high experience, *Gond, Panika, Baiga, Bheel*) aligned with similar species assemblages. Females and other tribes did not show a similarity with any of the mentioned groups.

Gaoue *et al*[3] suggested using theories and hypotheses to advance our understanding of people-plant interactions. *i.e.*, to understand how and why

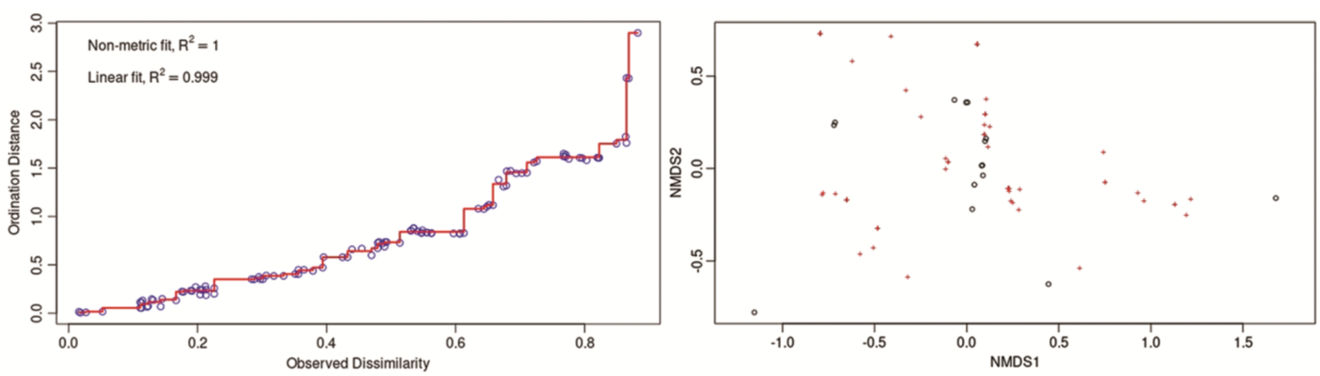

Fig. 3 — The stress plot (3a, upper panel) and the two-dimensional ordination (3b, lower panel). The species are depicted with a red '+' sign and the practitioner' characteristics as a circle

people select plants for ethnobotanical uses. Here, we have also tried to explain the choice of local traditional healers for the reported plants. The plant list exclusively contains species utilized for therapeutic purposes in other parts of the country (cosmopolitan plants). The selection of plants for medicinal purposes by local healers is very much governed by the demographic traits of the plants[3]. Bennet and Prance[26] suggested that many non-native medicinal plants were first introduced as food, ornamental, or for other non-medicinal use but subsequently used for medicinal purposes (*i.e.*, the versatility hypothesis). People will likely retain knowledge, use, and access to such plants that have a greater application for the population. Further, the use value and local abundance of some of the reported plants could be explained by the availability hypothesis, which argues that since the plants are locally abundant (easily accessible), they are part of local *Materia Medica*[27]. The observations that older people have greater knowledge of the local medicinal flora and no relationship between literacy and medicinal knowledge of the people, and close groups (e.g., Baiga Traditional healers) having a more uniform distribution of knowledge indicate the importance of social dynamics and human traits in plant selection in the area[28,29]. Readers are advised to see the debate on *Ethnobiology* 5 by Nabhan *et al*[30] and the references cited therein for an in-depth understanding of the subject.

Conclusions

Our world is witnessing a dramatic ecosystem and social change enforced by ongoing climate change, rising economic and social inequalities and health costs, and increasing loss of biological and linguistic diversity. Many believe that ethnobiologists are better equipped to address many of these challenges. In recent decades, ethnobotany has undergone serious transformations (*i.e.*, documentation to quantitative analyses to theory-inspired and hypothesis-driven inquiry). We used quantitative ethnobotanical analyses to analyze the socio-cultural and ecological significances of the ethnomedicinal flora for indigenous and tribal communities. The documented plants are used to treat various ailments caused by taxonomically unrelated pathogens. The ICS and IVI values affirm plants such as – *A. paniculata, C. macleodii, D. melanoxylon, H. coronarium, O. sanctum, S. robusta, T. chebula, T. cordifolia, C. caesia, and D. oojeinensis* have high cultural and ecological importance. Furthermore, we report that demography, social dynamics, and human traits are the drivers for the selection of plants by the local and traditional healers.

Supplementary Data

Supplementary data associated with this article is available in the electronic form at https://nopr.niscpr.res.in/jinfo/ijtk/IJTK_24(6)(2025) 555-565_SupplData.pdf

Acknowledgements

NKS thanks the Department of Science and Technology, New Delhi and Department of Biotechnology, New Delhi, for financial support under DST-FIST (SR/FST/LS-I/2018/132(C), and DBT-BUILDER [BT/INF/22/SP45361/2022; Project ID No. GAP-0104] programs.

Conflict of Interests

No conflict of interest amongst the authors.

Author Contributions

BSS collected the data, CMT and SB performed statistical analyses while NKS conceived the idea, designed the study, and wrote the manuscript.

Prior Informed Consent

The prior informed consent was obtained from all the informants.

Data Availability

All data are provided with the manuscript and can be made available by the corresponding author upon reasonable request. A part of the data has been borrowed from our previous publications[9,10].

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