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# Perspectives of traditional health care system of Sikkim, North-East India – An ethno-pharmacological survey and analysis

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The Indo-Himalayan Mountain state of Sikkim has abundant reserves of bio-diversity of ancient ancestry. Many folklore healers are renowned in Sikkim for their valuable traditional knowledge, especially for the use of combination drug therapy to treat bone fracture. In the cross-cultural ethnopharmacological survey, a predesigned questionnaire was used for interviews at the residence of respective folklore healers. Their patient handling and preparations of formulations have been documented in written and audio-visual format. The standard statistical indices selected relevant for the present study. The record of traditional knowledge on 193 different formulations used for 49 various human ailments have been enumerated during this survey. A total of 121 plants belonging to 65 families were found to be used as a component for 193 formulations. Graphical representation of the frequency of citation, especially survey and reference data shown significant correlation indicating common and specific use of plants in the treatment of different diseases. The scientific research on medicinal plants used by traditional practitioners and the application of ethnobotanical products in the folklore healthcare system significantly help in the sustainable development of traditional healthcare practices of the region. For the research fraternity, the quantitative analysis of survey data is gaining wider acceptability due to relative importance.

**Keywords**: Cross cultural ethnopharmacological survey, North East India, Predesigned questionnaire, Sikkim, Traditional healthcare practice, Traditional Knowledge, Traditional medicine

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Health issues across the globe are a universal perspective. Various traditional healers and practitioners perform treatments based on diverse principles and follow varied practices aiming towards a common goal of curing ailments to maintain a healthy livelihood among communities and, in turn, to society. This traditional knowledge exploration is a part of the cultural tradition of each community to establish a systematic approach based on traditional practices through the use of natural Bioresources. Besides healthcare development in the modern age, the communities prefer sharing their intellects on traditional practices and experiences, which includes the source of ailments and its remedies leading towards available methods to maintain healthy livelihood[1]. India is one of the mega biodiversity centers of the world, and a significant portion of biodiversity exists in its north-eastern region. The wealth of flora of this region amounts to nearly 43% of the country's total flora[2]. North-East India covers two global biodiversity hotspots, namely; Eastern Himalayas and Indo- Burma biodiversity hotspots. This region forms a unique biogeographic province encompassing major biomes recognized in the world comprising the most precious reservoir of plant diversity in India. In terms of biodiversity hotspots of the world, this region alone supports about 50% of India's biodiversity[3]. The traditional healthcare system is a common and widespread practice in the North-Eastern states of India, including the state of Sikkim. This Himalayan state in northeast India covers a geographical area of 7098 sq km, situated at Latitude 27-28˚N, longitude 88˚-89˚N, it has a general relief of 350- 857 m[4,5]. Sikkim has a significant portion of Eastern Himalaya surrounded by Tibet (north and northeastern side), Bhutan (east side), Nepal (west side), and West Bengal (South Side). The state is known for biodiversity, alpine and subtropical

climates and the highest peak in India and third highest on Earth, Kanchenjunga is located at Sikkim. Through several decades, Sikkim has passed through remarkable changes in its political structure, social structure, economic life, and culture. The traditional healthcare system has been established with their primary needs, historical background, modern societal realities, conditional logic and practices[1].

Sikkim comes under a crucial biodiversity hotspot and in the last two-centuries, maximum macrofauna and flora have been documented. The ethnic population living in rural areas of the state depends on folklore knowledge of the locally available bioresources for their healthcare in a remote high-altitude atmosphere and it's become a resource for survival. However, documentation was not in systematic written form and depended on oral tradition. Moreover, recent activities and urbanization irreversibly spoiled ancient knowledge[6]. Sikkim is rich in ethnic culture and vast biological diversity[7]. The native approaches of healing are based on locally available plant resources and are a vital part of social life and culture in Sikkim[4]. The native population traditionally uses many medicinal plants for their diseases in every rural village and community. A local folklore healthcare tradition exists due to those native experts practicing such treatments for human ailments[2]. Folklore healthcare practices with locally available resources have been passed orally over a generation by folklore healthcare practitioners to treat several human diseases that are firmly related to the spiritual principles and practices of the native population[8]. The native and local ethnic groups have been using traditional knowledge for centuries in their culture and healthcare practices. It was also regarded as a vital feature for the sustainable management of natural resources[9]. Ethnobotanical research is gaining much importance in recent years due to the limitations of modern medicine in control and/or cure of diseases. The growing interest in herbal products by a significant portion of the world population is due to negligible side effects with better efficacy. Immediate attention from the scientific fraternity is expected to validate claims made so far by the ethnic healers. The type and nature of data resulting from ethnopharmacological surveys (answers of questionnaires) are basically in primitive life, and the implementation of any statistical methods is cumbersome task.

Various plants and their parts were used predominantly for the preparation of herbal formulations (tuber, root, shoot, leaves, bark, flower, fruits, and plant as a whole). Formulations prepared have various dosage forms like powder, infusion, paste, decoction, oil, smoke, other types like salads, porridge, and juices. Some healers recommend freshly prepared doses along with additives like honey, sugar, candy, syrup, milk, water, salt, coconut oil, and so on. For specific medicine, the healer either uses a single plant or combination of plants[10-16]. Ethnic groups were passed their method of healing practices, knowledge of folk-medicine, or any other means of healing over the generation that is known as traditional medicine. Now, the computer and the internet are fast replacing the traditional knowledge system. The world has become a global village. With these backgrounds and our past experiences[17], in the present study, apart from documentation of traditional knowledge, we also have tried to explore cross-culture traditional healthcare practices of Sikkim intending to understand the scientific basis of traditional healthcare practices of the ethnic community of the Sikkim.

## Methodology

### Ethnopharmacological survey, documentation of traditional knowledge and collection

A cross-culture ethnopharmacological survey work on ‘Sikkim Traditional Healthcare Practices’ were done in continuation of our documentation work reported earlier[17]. The team comprising of a pharmacologist, researcher, and local staff in the related field from IBSD-Sikkim Centre, Gangtok, has formed the survey team for documentation of traditional knowledge in consultation with folklore healers of Sikkim. The First Phase of the ethnopharmacological survey was conducted in East Sikkim and South Sikkim districts of Sikkim (Fig. 1) with research permit of the department of forest, environment & wildlife management, Government of Sikkim, Gangtok (F. no. 78/GOS/FEWMD/BD-R 2015/CCF(T&HQ)35 dated May 15, 2017) and Permission of Home Department, Government of Sikkim, Gangtok (No. Home/Confdl/149/2016/03/817 dated June 19, 2017). The standard protocol was followed as designed for the earlier survey[17]. In brief, a total of eleven traditional healthcare practitioners were interviewed in person for their traditional practices, including the diseases they treat, the composition of formulations, mode/methods of preparation of traditional medicines, application, doses and efficacy of the treatment. The

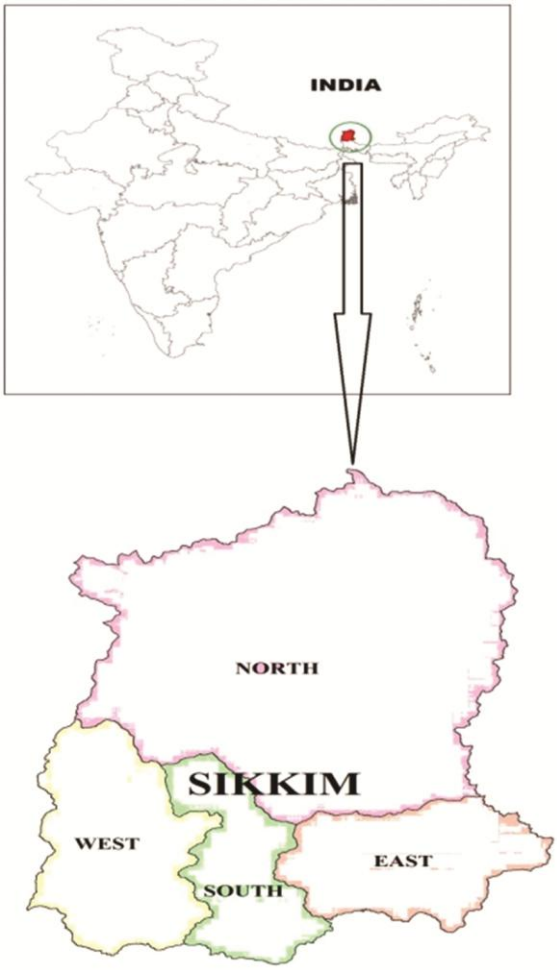


Fig. 1 — Location of surveyed area (Sikkim State, North-East India)

ethnopharmacological details and information was recorded as written documents in pre-designed formats. The voice recording, still photography, and videography were also done. A predesigned 'letter of consent form' was explained to all individual folklore healers in their respective local language and obtained their signature/written permission to use their traditional healthcare knowledge, still photography and videography during the survey for research and publication. The survey team also interacted with the patients treated by the respective practitioner during documentation work, and feedbacks have recorded as and when required.

***Compilation of data***

The comprehensive information on traditional medicine resources for treatment will be extremely useful in modern research. All data were compiled in a scientific manner that will provide integrated details about the dosage form, the plant used, part used, type of dosage, details of healers, plant name (local, universal, scientific), uses (general and specific). The ethnomedicinal uses of the bioresources have been documented and compared with available published literature (secondary data). The other medicinal uses of respective bioresources in other parts of the India/World were found out.

**Data analysis**

The data set were obtained from the direct questionnaire from the traditional ethnic healers from Sikkim and adjoining districts of Sikkim. The primary data was normalized using MS excel sheet. The standard statistical indices relevant for the present study were selected. The indices calculated were: Informant Consensus Factor (ICF), Frequency of Citation (FoC), Relative Frequency of Citation (RFC), User Value (UV) and Family Importance Value (FIV) using the standard formula mentioned below.

***Descriptive statistics***

Quantitative ethnobotany first used by Prance (1987)[18,19] was subsequently used by the research fraternity for the estimation of popular species used by native/local people. The selection of appropriate statistical indices is a crucial step while estimating the significance of ethnobotanical data. The statistical indices provide useful hints towards the frequent use of specific species in general and medicinal importance in particular. The general criteria used for selection are method explicit, sensitivity to sampling intensity, time for annotation, statistical estimation, user value, useful species, accuracy, reproducibility, comparable, redundancy, data dependency, and dynamic nature of indices used[20-22].

***Informant consensus factor (ICF)***

The maximum ICF value close to 1 indicates well-known plant species used due to the authenticity of medicine used in the treatment of disease[16].

$$\mathrm{ICF} = \frac{\mathrm{Nur} - \mathrm{Nt}}{\mathrm{Nur} - 1}$$

Where, Nur = Number of reports for a particular use category; Nt = Number of taxa used for particular use category by all the informant. However, ICF value 0 represents rare or no use of the plant by the informant.

***Frequency of Citation (FoC)***

FoC signifies the local use of species[23,24]. The descriptive statistics calculations for FoC values

provide information about the plant species having the highest FoC will provide further useful insight for probable new species of interest.

$$\text{FoC} = \frac{\text{Number of citation of that particular species}}{\text{total number of all citation for all species}} \text{ X } 100$$

Separate calculations were performed for FoC for survey and reference species used by the informants. The resultant value shows considerable variation among the survey and reference dataset subject to the use of specific species.

***Relative Frequency of Citation (RFC)***

An RFC value signifies the local importance of species[16]. The descriptive statistics calculations for RFC values provide information about the plant species cited by informants.

$$\text{RFC} = \frac{\text{FC}}{\text{N}} \qquad (0< \text{RFC} <1)$$

Where FC= Total number of informants citing particular species; N= Total number of informants participated in the study.

***Fidelity Level (FL %)***

FL depicts specific plants used for particular diseases in a particular area[16].

$$\text{FL} = \frac{\text{Np}}{\text{N}} \text{ x } 100$$

Where, Np = Total number of informants citing particular plant used in treatment of a specific disease; N = Total number of informants invoking the plant species used for a specific disease.

***Family Importance Value (FIV)***

Elaborates local importance of species or family and is the ratio of a total number of informants citing a particular family of plant species by a total number of informants who participated in the ethnobotanical survey[12].

$$\text{FIV} = \frac{\text{FC(Family)}}{\text{N}} \text{ x } 100$$

Where, FC = Total number of informants mentioning plant family in treatment; N = Total number of informants participated in the study.

***User Value (UV)***

First used by Phillips and Gentry (1993a and 1993b)[12,16,25,26] and it imparts relative importance of uses of plant species[27,28] and calculated by the following formula:

$$\text{UV} = \frac{\sum \text{Ui}}{\text{N}}$$

Where U is uses recorded for individual plant species; N= Total number of Informants.

The bubble plot for RFC and UV shown the species used frequently, and the use of that species is significant. Principal components analysis of RFC and UV also confirms the frequency of citation of species is corresponding to the user. The PAST (PA leontological STatistics) software was used for calculating PCA and bubble plot[29].

## Results

**Cross-cultural ethnopharmacological survey on Sikkim Traditional Medicine (STM)**

The IBSD-Sikkim Centre, Gangtok survey team surveyed traditional knowledge in two districts of Sikkim. Altogether, eleven traditional practitioners in two districts, which belong to three different ethnic communities were interviewed. The records of traditional knowledge on 193 different formulations used for 49 various human ailments were enacted from this survey. One hundred twenty-one different plant products and six various organic/inorganic matters (sugar, salt, etc.) were found to be used as a component of 193 formulations. The survey report was compiled in print and audio-visual format. The photographs of the survey of two districts are given in Figure 2. The list of the plant bioresources is given in Table 1. The formulations of plant resources used by traditional practitioners of Sikkim have been tabulated in Supplementary Table S1 in which, name of plant parts used, mode of preparation, diseases treated, duration of use, and doses were provided as documented during the survey. The details of traditional practitioners are given as Supplementary Table S2.

## Data analysis

Amongst all the informants, the maximum conveyed that the reason for the choice of ethnomedicine system was their belief in the safety and low adverse effects associated with natural herbal

Table 1 — Documented ethnomedicinal plants studies with statistical indices Frequency of Citation for primary data (S) and Secondary data (R). *(contd.)*

| S/N | Scientific Name of plant and Specimen No. | Local Name | Family | Fidelity level (%) | RFC | UV | No. of Informants | | Used in Disease condition | | Frequency of citation (FoC) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | S | R | S | R | S | R |
| 1 | *Psidium guajava* Linn. IBSD-SC/EPS/2016/IP/02 | *Ambak* | Myrtaceae | 100 | 0.18 | 1 | 2 | 13 | 2 | 17 | 18.18 | 17.81 |
| 2 | *Azadirachta indica* A.Juss IBSD-SC/EPS/2016/IP/05 | *Neem pati* | Meliaceae | 66.67 | 0.18 | 0.67 | 2 | 18 | 3 | 45 | 18.18 | 24.66 |
| 3 | *Swertia chirayita* (Roxb. ex Fleming.) H.Karst. IBSD-SC/EPS/2016/IP/06 | *Chiraita* | Gentianaceae | 100 | 0.27 | 1 | 3 | 6 | 3 | 5 | 27.27 | 8.22 |
| 4 | *Kaempferia rotunda* Linn. IBSD-SC/EPS/2016/IP/07 | *Bhui Champa* | Zingiberaceae | 41.67 | 0.45 | 0.42 | 5 | 4 | 12 | 9 | 45.45 | 5.48 |
| 5 | *Viscum articulatum* Burm f. IBSD-SC/EPS/2016/IP/08 | *Harchur* | Viscaceae | 83.33 | 0.45 | 0.83 | 5 | 3 | 6 | 6 | 45.45 | 4.11 |
| 6 | *Berginia ciliate* Sternb. IBSD-SC/EPS/2016/IP/09 | *Pakhenbed* | Saxifragaceae | 55.56 | 0.45 | 0.56 | 5 | 4 | 9 | 5 | 45.45 | 5.48 |
| 7 | *Alstonia scholaris* (L.) R.Br. IBSD-SC/EPS/2016/IP/10 | *Chatiwan* | Apocynaceae | 100 | 0.18 | 1 | 2 | 10 | 2 | 14 | 18.18 | 13.70 |
| 8 | *Ocimum sanctum* Linn. IBSD-SC/EPS/2016/IP/11 | *Tulsi* | Lamiaceae | 50 | 0.18 | 0.5 | 2 | 10 | 4 | 25 | 18.18 | 13.70 |
| 9 | *Centella asiatica* (L.) Urban IBSD-SC/EPS/2016/IP/13 | *Golpatta* | Apiaceae | 100 | 0.18 | 1 | 2 | 16 | 2 | 27 | 18.18 | 21.92 |
| 10 | *Phytolacca acinosa*Roxb. IBSD-SC/EPS/2016/IP/14 | *Jaringo* | Phytolaccaceae | 33.3 | 0.09 | 0.33 | 1 | 1 | 3 | 2 | 9.09 | 1.37 |
| 11 | *Plumbago indica* Linn. IBSD-SC/EPS/2016/IP/15 | *Chittu* | Plumbaginaceae | 33.3 | 0.09 | 0.33 | 1 | 2 | 3 | 4 | 9.09 | 2.74 |
| 12 | *Commelina bengalensis* Linn. IBSD-SC/EPS/2016/IP/12 | *Kanayjhar* | Commelinaceae | 25 | 0.18 | 0.25 | 2 | 6 | 8 | 10 | 18.18 | 8.22 |
| 13 | *Bridelia retusa* (L.) A.Juss. IBSD-SC/EPS/2016/IP/13 | *Gayo* | Euphorbiaceae | 20 | 0.099 | 0.2 | 1 | 1 | 5 | 2 | 9.09 | 1.37 |
| 14 | *Bauhinia purpurea* Linn IBSD-SC/EPS/2016/IP/14 | *Taaki* | Caesalpiniaceae | 100 | 0.09 | 1 | 1 | 2 | 1 | 5 | 9.09 | 2.74 |
| 15 | *Aloe barbadensis* Miller IBSD-SC/EPS/2016/IP/15 | *Ghewkumari* | Liliaceae | 28.57 | 0.18 | 0.28 | 2 | 10 | 7 | 16 | 18.18 | 13.70 |
| 16 | *Rumex nepalensis* Spreng. IBSD-SC/EPS/2016/IP/16 | *Halhaley* | Polygonaceae | 50 | 0.09 | 0.5 | 1 | 3 | 2 | 5 | 9.09 | 4.11 |
| 17 | *Bombax ceiba* Linn. IBSD-SC/EPS/2016/IP/17 | *Simal* | Bombacaceae | 50 | 0.09 | 0.5 | 1 | 7 | 2 | 10 | 9.09 | 9.59 |
| 18 | *Abroma augustum* (L.) J.A.Murray IBSD-SC/EPS/2016/IP/18 | *Kapasey* | Malvaceae | 100 | 0.09 | 1 | 1 | 3 | 1 | 5 | 9.09 | 4.11 |
| 19 | *Euphorbia hirta* Linn. IBSD-SC/EPS/2016/IP/19 | *Bhui Chiplay* | Euphorbiaceae | 33.33 | 0.18 | 0.33 | 2 | 7 | 6 | 13 | 18.18 | 9.59 |
| 20 | *Trigonella foenum-graecum* Linn. IBSD-SC/EPS/2016/IP/20 | *Methi* | Fabaceae | 25 | 0.09 | 0.25 | 1 | 3 | 4 | 5 | 9.09 | 4.11 |
| 21 | *Drymaria cordata* (L) Willd.exRoem. & Schult IBSD-SC/EPS/2016/IP/21 | *Abijalo* | Caryophyllaceae | 50 | 0.18 | 0.5 | 2 | 8 | 4 | 9 | 18.18 | 10.96 |
| 22 | *Curcuma zedoaria* (Christm.) Roscoe IBSD-SC/EPS/2016/IP/22 | *KaloHardi* | Zingiberaceae | 50 | 0.27 | 0.5 | 3 | 5 | 6 | 9 | 27.27 | 6.85 |

*(contd.)*

Table 1 — Documented ethnomedicinal plants studies with statistical indices Frequency of Citation for primary data (S) and Secondary data (R). *(contd.)*

| S/N | Scientific Name of plant and Specimen No. | Local Name | Family | Fidelity level (%) | RFC | UV | No. of Informants | | Used in Disease condition | | Frequency of citation (FoC) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | S | R | S | R | S | R |
| 24 | *Edgeworthia sp.* IBSD-SC/EPS/2016/IP/24 | *Kalokagatay* | Thymelaeaceae | 100 | 0.09 | 1 | 1 | 2 | 1 | 6 | 9.09 | 2.74 |
| 25 | *Citrus aurantifolia* (Christm. &Panz.) Swingle IBSD-SC/EPS/2016/IP/25 | *Nimbu* | Rutaceae | 25 | 0.09 | 0.25 | 1 | 1 | 4 | 3 | 9.09 | 1.37 |
| 26 | *Calotropis gigantean* (L.) W. T. Aiton IBSD-SC/EPS/2016/IP/26 | *Aank* | Asclepiadaceae | 100 | 0.09 | 1 | 1 | 7 | 1 | 7 | 9.09 | 9.59 |
| 27 | *Mangifera indica* Linn. IBSD-SC/EPS/2016/IP/27 | *Mango* | Anacardiaceae | 50 | 0.09 | 0.5 | 1 | 11 | 2 | 17 | 9.09 | 15.07 |
| 28 | *Urtica parvifora* Roxb. IBSD-SC/EPS/2016/IP/28 | *Sishnu* | Urticaceae | 33.33 | 0.09 | 0.33 | 1 | 1 | 3 | 1 | 9.09 | 1.37 |
| 29 | *Mentha viridis* Linn. IBSD-SC/EPS/2016/IP/29 | *Pudina* | Lamiaceae | 100 | 0.18 | 1 | 2 | 2 | 2 | 5 | 18.18 | 2.74 |
| 30 | *Spinacia oleracea* Linn. IBSD-SC/EPS/2016/IP/30 | *Palak* | Chenopodiaceae | 100 | 0.18 | 1 | 2 | 1 | 2 | 1 | 18.18 | 1.37 |
| 31 | *Trachyspermum ammi* Linn. IBSD-SC/EPS/2016/IP/31 | *Jwano* | Apiaceae | 100 | 0.18 | 1 | 2 | 1 | 2 | 3 | 18.18 | 1.37 |
| 32 | *Astilberi vularis* Buchanan-Hamilton ex D. Don. IBSD-SC/EPS/2016/IP/32 | *Buro-okhati* | Saxifragaceae | 13.33 | 0.18 | 0.133 | 2 | 1 | 15 | 2 | 18.18 | 1.37 |
| 33 | *Lepidium sp.* IBSD-SC/EPS/2016/IP/33 | *Chausur* | Brassicaceae | 33.33 | 0.09 | 0.33 | 1 | 1 | 3 | 20 | 9.09 | 1.37 |
| 34 | *Prunus cerasoides* D.Don. IBSD-SC/EPS/2016/IP/34 | *Payun* | Rosaceae | 50 | 0.09 | 0.5 | 1 | 2 | 2 | 2 | 9.09 | 2.74 |
| 35 | *Rubus sp.* IBSD-SC/EPS/2016/IP/35 | *Kalo Aiselu* | Rosaceae | 100 | 0.09 | 1 | 1 | 3 | 1 | 18 | 9.09 | 4.11 |
| 36 | *Brassica nigra* (L.) W.D.J. Koch. IBSD-SC/EPS/2016/IP/36 | *Tori* | Brassicaceae | 50 | 0.09 | 0.5 | 1 | 1 | 2 | 1 | 9.09 | 1.37 |
| 37 | *Bacopa monnieri* Linn. IBSD-SC/EPS/2016/IP/37 | *Brahmi* | Scrophulariaceae | 100 | 0.09 | 1 | 1 | 4 | 1 | 11 | 9.09 | 5.48 |
| 38 | *Triticum aestivum* L.em. Thell. IBSD-SC/EPS/2016/IP/38 | *Gahu (Oats)* | Poaceae | 50 | 0.09 | 0.5 | 1 | 2 | 2 | 2 | 9.09 | 2.74 |
| 39 | *Adina cordifolia* (Roxb.)Brandis. IBSD-SC/EPS/2016/IP/39 | *Haledu* | Rubiaceae | 100 | 0.09 | 1 | 1 | 1 | 1 | 1 | 9.09 | 1.37 |
| 40 | *Terminalia chebula* Retz. IBSD-SC/EPS/2016/IP/40 | *Harra* | Combretaceae | 44.44 | 0.36 | 0.44 | 4 | 17 | 9 | 41 | 36.36 | 23.29 |
| 41 | *Carica papaya* Linn. IBSD-SC/EPS/2016/IP/41 | *Papaya* | Caricaceae | 33.33 | 0.09 | 0.33 | 1 | 8 | 3 | 11 | 9.09 | 10.96 |
| 42 | *Saccharum officinarum* Linn. IBSD-SC/EPS/2016/IP/42 | *Sugarcane* | Poaceae | 100 | 0.09 | 1 | 1 | 5 | 1 | 3 | 9.09 | 6.85 |
| 43 | *Podophyllum hexandrum* Royle IBSD-SC/EPS/2016/IP/43 | *Ban kakri, Laghupatra* | Podophyllaceae | 11.11 | 0.09 | 0.11 | 1 | 3 | 9 | 6 | 9.09 | 4.11 |
| 44 | *Sapindus mukorossi* Gaertn. IBSD-SC/EPS/2016/IP/44 | *Reetha* | Sapindaceae | 100 | 0.18 | 1 | 2 | 3 | 2 | 5 | 18.18 | 4.11 |

(*contd.*)

Table 1 — Documented ethnomedicinal plants studies with statistical indices Frequency of Citation for primary data (S) and Secondary data (R). *(contd.)*

| S/N | Scientific Name of plant and Specimen No. | Local Name | Family | Fidelity level (%) | RFC | UV | No. of Informants | | Used in Disease condition | | Frequency of citation (FoC) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | *Rhus succedanea* Linn. IBSD-SC/EPS/2016/IP/45 | *Bhalayo* | Anacardiaceae | 50 | 0.09 | 0.5 | 1 | 1 | 2 | 11 | 9.09 | 1.37 |
| 46 | *Entada scandens* (L.) Benth IBSD-SC/EPS/2016/IP/46 | *Pangra* | Mimosaceae | 66.67 | 0.18 | 0.67 | 2 | 1 | 3 | 3 | 18.18 | 1.37 |
| 47 | *Datura fastuosa* Linn. IBSD-SC/EPS/2016/IP/47 | *Kalo Dhaturo* | Solanaceae | 100 | 0.18 | 1 | 2 | 9 | 2 | 10 | 18.18 | 12.33 |
| 48 | *Phyllanthus emblica* Linn. IBSD-SC/EPS/2016/IP/48 | *Amla* | Euphorbiaceae | 60 | 0.27 | 0.6 | 3 | 14 | 5 | 42 | 27.27 | 19.18 |
| 49 | *Terminalia bellirica* (Gaertn.) Roxb. IBSD-SC/EPS/2016/IP/49 | *Barra* | Combretaceae | 66.67 | 0.18 | 0.67 | 2 | 7 | 3 | 23 | 18.18 | 9.59 |
| 50 | *Rubia cordifolia* Linn. IBSD-SC/EPS/2016/IP/50 | *Majito* | Rubiaceae | 50 | 0.09 | 0.5 | 1 | 8 | 2 | 8 | 9.09 | 10.96 |
| 51 | *Engelhardtia spicata* Lesch. ex Blume IBSD-SC/EPS/2016/IP/51 | *Mauwa* | Juglandaceae | 100 | 0.09 | 1 | 1 | 2 | 1 | 2 | 9.09 | 2.74 |
| 52 | *Campylandra aurantiaca* Baker IBSD-SC/EPS/2016/IP/52 | *Nakimbo* | Asparagaceae | 50 | 0.09 | 0.5 | 1 | 1 | 2 | 8 | 9.09 | 1.37 |
| 53 | *Clematis buchananiana* de Candolle IBSD-SC/EPS/2016/IP/53 | *Pinas lahara* | Ranunculaceae | 42.85 | 0.27 | 0.43 | 3 | 2 | 7 | 2 | 27.27 | 2.74 |
| 54 | *Tinospora cordifolia* (Thunb.) Miers IBSD-SC/EPS/2016/IP/54 | *Gurjo* | Menispermaceae | 22.22 | 0.18 | 0.22 | 2 | 13 | 9 | 26 | 18.18 | 17.81 |
| 55 | *Mimosa pudica* Linn. IBSD-SC/EPS/2016/IP/55 | *Buhari jhar* | Mimosaceae | 100 | 0.09 | 1 | 1 | 8 | 1 | 11 | 9.09 | 10.96 |
| 56 | *Smilax zeylanica* Linn. IBSD-SC/EPS/2016/IP/56 | *Kukurdainu* | Smilacaceae | 100 | 0.09 | 1 | 1 | 2 | 1 | 6 | 9.09 | 2.74 |
| 57 | *Equisetum debile* Roxb. ex Vaucher IBSD-SC/EPS/2016/IP/57 | *Salli-bisalli* | Equisetaceae | 33.33 | 0.09 | 0.33 | 1 | 1 | 3 | 1 | 9.09 | 1.37 |
| 58 | *Pteris sp.* IBSD-SC/EPS/2016/IP/58 | *Kaloniguro* | Pteridaceae | 20 | 0.09 | 0.2 | 1 | 8 | 5 | 4 | 9.09 | 10.96 |
| 59 | *Mirabilis jalapa* Linn. IBSD-SC/EPS/2016/IP/59 | *Lankasani (Red)* | Nyctaginaceae | 100 | 0.09 | 1 | 1 | 3 | 1 | 6 | 9.09 | 4.11 |
| 60 | *Betula utilis* D.Don IBSD-SC/EPS/2016/IP/60 | *Saur* | Betulaceae | 100 | 0.09 | 1 | 1 | 4 | 1 | 12 | 9.09 | 5.48 |
| 61 | *Coriandrum sativum* Linn. IBSD-SC/EPS/2016/IP/61 | *Dhania* | Apiaceae | 100 | 0.09 | 1 | 1 | 1 | 1 | 2 | 9.09 | 1.37 |
| 62 | *Allium sativum* Linn. IBSD-SC/EPS/2016/IP/62 | *Lasun* | Amaryllidaceae | 50 | 0.09 | 0.5 | 1 | 3 | 2 | 7 | 9.09 | 4.11 |
| 63 | *Artemisia vulgaris* Linn. IBSD-SC/EPS/2016/IP/63 | *Titepati* | Asteraceae | 4 | 0.09 | 0.04 | 1 | 1 | 25 | 3 | 9.09 | 1.37 |
| 64 | *Rubus calycinus*Wallich ex D. Don IBSD-SC/EPS/2016/IP/64 | *Aiselu* | Rosaceae | 100 | 0.09 | 1 | 1 | 1 | 1 | 1 | 9.09 | 1.37 |
| 65 | *Heracleum wallichii DC.* IBSD-SC/EPS/2016/IP/65 | *Chimphing* | Apiaceae | 30 | 0.27 | 0.3 | 3 | 2 | 10 | 3 | 27.27 | 2.74 |

(*contd.*)

Table 1 — Documented ethnomedicinal plants studies with statistical indices Frequency of Citation for primary data (S) and Secondary data (R). *(contd.)*

| S/N | Scientific Name of plant and Specimen No. | Local Name | Family | Fidelity level (%) | RFC | UV | No. of Informants | | Used in Disease condition | | Frequency of citation (FoC) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 66 | *Lindera neesiana* (Wallich ex Nees) Kurz. IBSD-SC/EPS/2016/IP/66 | *Siltimur* | Lauraceae | 33.33 | 0.09 | 0.33 | 1 | 1 | 3 | 3 | 9.09 | 1.37 |
| 67 | *Evodia fraxinifolia* (Hook.) Benth. IBSD-SC/EPS/2016/IP/67 | *Khanakpa* | Rutaceae | 100 | 0.27 | 1 | 3 | 1 | 3 | 1 | 27.27 | 1.37 |
| 68 | *Dichroa febrifuga* Lour IBSD-SC/EPS/2016/IP/68 | *Basak* | Hydrangeaceae | 100 | 0.18 | 1 | 2 | 1 | 2 | 2 | 18.18 | 1.37 |
| 69 | *Oroxylum indicum* (L.) Kurz. IBSD-SC/EPS/2016/IP/69 | *Totala* | Bignoniaceae | 75 | 0.27 | 0.75 | 3 | 10 | 4 | 17 | 27.27 | 13.70 |
| 70 | *Cassia fistula* Linn. IBSD-SC/EPS/2016/IP/70 | *Rajvriksha* | Caesalpiniaceae | 50 | 0.09 | 0.5 | 1 | 9 | 2 | 45 | 9.09 | 12.33 |
| 71 | *Litsea citrate* Blume IBSD-SC/EPS/2016/IP/71 | *Sil-timbur* | Lauraceae | 100 | 0.09 | 1 | 1 | 1 | 1 | 1 | 9.09 | 1.37 |
| 72 | *Docynia indica* (Wall.) Decne. IBSD-SC/EPS/2016/IP/72 | *Mael* | Rosaceae | 50 | 0.09 | 0.5 | 1 | 2 | 2 | 4 | 9.09 | 2.74 |
| 73 | *Rubus ellipticus* Sm. IBSD-SC/EPS/2016/IP/73 | *Aiselu* | Rosaceae | 66.67 | 0.18 | 0.67 | 2 | 4 | 3 | 5 | 18.18 | 5.48 |
| 74 | *Bauhinia vahlii* Wight &Arn. IBSD-SC/EPS/2016/IP/74 | *Bhorla* | Caesalpiniaceae | 66.67 | 0.18 | 0.67 | 2 | 1 | 3 | 1 | 18.18 | 1.37 |
| 75 | *Eupatorium cannabinum* Linn. IBSD-SC/EPS/2016/IP/75 | *Banmara* | Asteraceae | 25 | 0.09 | 0.25 | 1 | 1 | 4 | 4 | 9.09 | 1.37 |
| 76 | *Adiantum phillippense* Linn. IBSD-SC/EPS/2016/IP/76 | *Tharouneu* | Pteridaceae | 25 | 0.09 | 0.25 | 1 | 1 | 4 | 1 | 9.09 | 1.37 |
| 77 | *Artocarpus heterophyllus* Lam. IBSD-SC/EPS/2016/IP/77 | *Rukh Katar* | Moraceae | 100 | 0.09 | 1 | 1 | 3 | 1 | 6 | 9.09 | 4.11 |
| 78 | *Passiflora nepalensis* Wall. IBSD-SC/EPS/2016/IP/78 | *Garindal* | Passifloraceae | 50 | 0.09 | 0.5 | 1 | 1 | 2 | 1 | 9.09 | 1.37 |
| 79 | *Cynodon dactylon* (L.) Pers. IBSD-SC/EPS/2016/IP/79 | *Dubo* | Poaceae | 50 | 0.18 | 0.5 | 2 | 14 | 4 | 15 | 18.18 | 19.18 |
| 80 | *Cuscuta reflexa* Roxb. IBSD-SC/EPS/2016/IP/80 | *Akashveli* | Convulvulaceae | 100 | 0.09 | 1 | 1 | 6 | 1 | 8 | 9.09 | 8.22 |
| 81 | *Fraxinus floribunda* Wall. IBSD-SC/EPS/2016/IP/81 | *Lakuri* | Oleaceae | 42.85 | 0.27 | 0.43 | 3 | 1 | 7 | 2 | 27.27 | 1.37 |
| 82 | *Acorus calamus* Linn. IBSD-SC/EPS/2016/IP/82 | *Bojho* | Araceae | 50 | 0.09 | 0.5 | 1 | 12 | 2 | 28 | 9.09 | 16.44 |
| 83 | *Eichhornia crassipes* (Mart.) Solms IBSD-SC/EPS/2016/IP/83 | *Indra Kamal* | Pontederiaceae | 100 | 0.18 | 1 | 2 | 0 | 2 | 0 | 18.18 | 0.00 |
| 84 | *Saraca ashoka* (Roxb.)Willd. IBSD-SC/EPS/2016/IP/84 | *Ashoka Tree* | Caesalpiniaceae | 100 | 0.18 | 1 | 2 | 1 | 2 | 1 | 18.18 | 1.37 |
| 85 | *Mesua ferrea* Linn. IBSD-SC/EPS/2016/IP/85 | *Nageswari* | Clusiaceae | 33.33 | 0.09 | 0.33 | 1 | 3 | 3 | 3 | 9.09 | 4.11 |
| 86 | *Abies densa* Griff. IBSD-SC/EPS/2016/IP/86 | *Ailey* | Pinaceae | 50 | 0.09 | 0.5 | 1 | 1 | 2 | 3 | 9.09 | 1.37 |
| 87 | *Bauhinia variegate* (L.) Benth. IBSD-SC/EPS/2016/IP/87 | *Taki* | Caesalpiniaceae | 33.33 | 0.09 | 0.33 | 1 | 4 | 3 | 18 | 9.09 | 5.48 |
| 88 | *Cannabis sativa* Linn. IBSD-SC/EPS/2016/IP/88 | *Ganja,Bhang* | Cannabaceae | 100 | 0.09 | 1 | 1 | 7 | 1 | 18 | 9.09 | 9.59 |

(*contd.*)

Table 1 — Documented ethnomedicinal plants studies with statistical indices Frequency of Citation for primary data (S) and Secondary data (R). *(contd.)*

| S/N | Scientific Name of plant and Specimen No. | Local Name | Family | Fidelity level (%) | RFC | UV | No. of Informants | | Used in Disease condition | | Frequency of citation (FoC) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 89 | *Cheilocostus speciosus* (J.Konig)Sm. IBSD-SC/EPS/2016/IP/89 | *Bet Lauree* | Costaceae | 50 | 0.18 | 0.5 | 2 | 10 | 4 | 11 | 18.18 | 13.70 |
| 90 | *Rhododendron arboretum* Sm. IBSD-SC/EPS/2016/IP/90 | *Lali-Gurans* | Ericaceae | 12.5 | 0.09 | 0.125 | 1 | 6 | 8 | 10 | 9.09 | 8.22 |
| 91 | *Rhododendron campanulatum* D.Don. IBSD-SC/EPS/2016/IP/91 | *Gurans* | Ericaceae | 25 | 0.09 | 0.25 | 1 | 4 | 4 | 7 | 9.09 | 5.48 |
| 92 | *Zingiber officinale* Roscoe. IBSD-SC/EPS/2016/IP/92 | *Aduwa* | Zingiberaceae | 25 | 0.09 | 0.25 | 1 | 10 | 4 | 11 | 9.09 | 13.70 |
| 93 | *Abies forrestii* Coltm.-Rog. IBSD-SC/EPS/2016/IP/93 | *Bobresall* | Pinaceae | 12.5 | 0.09 | 0.125 | 1 | 0 | 8 | 0 | 9.09 | 0.00 |
| 94 | *Abies webiana* Lindl. IBSD-SC/EPS/2016/IP/94 | *Sala* | Pinaceae | 100 | 0.09 | 1 | 1 | 1 | 1 | 4 | 9.09 | 1.37 |
| 95 | *Aconitum ferox* Wall. ex Ser. IBSD-SC/EPS/2016/IP/95 | *Bikh, Bikhma* | Ranunculaceae | 11.11 | 0.09 | 0.11 | 1 | 3 | 9 | 5 | 9.09 | 4.11 |
| 96 | *Aconitum heterophyllum* Wall. IBSD-SC/EPS/2016/IP/96 | *Bikh, Paunkar* | Ranunculaceae | 25 | 0.09 | 0.25 | 1 | 5 | 4 | 7 | 9.09 | 6.85 |
| 97 | *Angelica archangelica* Linn. IBSD-SC/EPS/2016/IP/97 | *Khomog* | Apiaceae | 14.28 | 0.09 | 0.14 | 1 | 1 | 7 | 1 | 9.09 | 1.37 |
| 98 | *Asparagus recemosus* Willd. IBSD-SC/EPS/2016/IP/98 | *Satamuli* | Asparagaceae | 16.67 | 0.09 | 0.167 | 1 | 12 | 6 | 22 | 9.09 | 16.44 |
| 99 | *Callicarpa macrophylla* Vahl. IBSD-SC/EPS/2016/IP/99 | *Patharwar* | Lamiaceae | 12.5 | 0.09 | 0.125 | 1 | 3 | 8 | 4 | 9.09 | 4.11 |
| 100 | *Celastrus paniculatus* Willd. IBSD-SC/EPS/2016/IP/100 | *Runglim* | Celastraceae | 25 | 0.09 | 0.25 | 1 | 3 | 4 | 5 | 9.09 | 4.11 |
| 101 | *Cinnamomum tamala* Buch.-Ham.) T.Nees&C.H.Eberm. IBSD-SC/EPS/2016/IP/101 | *Choti, Sinkoli* | Lauraceae | 6.25 | 0.09 | 0.0625 | 1 | 4 | 16 | 9 | 9.09 | 5.48 |
| 102 | *Hedychium spicatum* Ham-ex-Smith IBSD-SC/EPS/2016/IP/102 | *Kapur kacheri* | Zingiberaceae | 20 | 0.09 | 0.2 | 1 | 4 | 5 | 8 | 9.09 | 5.48 |
| 103 | *Mallotus philippensis* (Lam.) Muell.Arg. IBSD-SC/EPS/2016/IP/103 | *Sinduria, Puroa, Safed mallata* | Euphorbiaceae | 20 | 0.09 | 0.2 | 1 | 3 | 5 | 3 | 9.09 | 4.11 |
| 104 | *Nardostachys jatamansi* (D.Don) DC. IBSD-SC/EPS/2016/IP/104 | *Japoy* | Valerianaceae | 6.25 | 0.09 | 0.0625 | 1 | 7 | 16 | 8 | 9.09 | 9.59 |
| 105 | *Paederia foetida* Linn. IBSD-SC/EPS/2016/IP/105 | *Biri, Berihara* | Rubiaceae | 7.69 | 0.09 | 0.077 | 1 | 8 | 13 | 13 | 9.09 | 10.96 |
| 106 | *Saussuria lappa* Clarke. IBSD-SC/EPS/2016/IP/106 | *Asolow, Brahma kamal* | Asteraceae | 14.28 | 0.09 | 0.14 | 1 | 2 | 7 | 4 | 9.09 | 2.74 |
| 107 | *Smilax lanceifolia* Roxb. IBSD-SC/EPS/2016/IP/107 | *Kukur, Ramdatun* | Smilacaceae | 16.67 | 0.09 | 0.167 | 1 | 2 | 6 | 2 | 9.09 | 2.74 |
| 108 | *Taxus baccata* Linn. IBSD-SC/EPS/2016/IP/108 | *Dhengresalla* | Taxaceae | 10 | 0.09 | 0.1 | 1 | 2 | 10 | 5 | 9.09 | 2.74 |
| 109 | *Valeriana hardwickii* Wall. IBSD-SC/EPS/2016/IP/109 | *Chammaha* | Valerianaceae | 20 | 0.09 | 0.2 | 1 | 1 | 5 | 7 | 9.09 | 1.37 |
| 110 | *Zanthoxylum alatum* Roxb. IBSD-SC/EPS/2016/IP/110 | *Tumuru* | Rutaceae | 16.67 | 0.09 | 0.167 | 1 | 2 | 6 | 3 | 9.09 | 2.74 |
| 110 | *Zanthoxylum alatum* Roxb. IBSD-SC/EPS/2016/IP/110 | *Tumuru* | Rutaceae | 16.67 | 0.09 | 0.167 | 1 | 2 | 6 | 3 | 9.09 | 2.74 |

(*contd.*)

Table 1 — Documented ethnomedicinal plants studies with statistical indices Frequency of Citation for primary data (S) and Secondary data (R). *(contd.)*

| S/N | Scientific Name of plant and Specimen No. | Local Name | Family | Fidelity level (%) | RFC | UV | No. of Informants | | Used in Disease condition | | Frequency of citation (FoC) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 111 | *Aeschynanthus sikkimensis* C.B.Clarke) Stapf. IBSD-SC/EPS/2016/IP/111 | *Baklaypatay* | Gesneriaceae | 20 | 0.09 | 0.2 | 1 | 1 | 5 | 1 | 9.09 | 1.37 |
| 112 | *Alnus nepalensis* D.Don. IBSD-SC/EPS/2016/IP/112 | *Utis* | Betulaceae | 20 | 0.09 | 0.2 | 1 | 2 | 5 | 3 | 9.09 | 2.74 |
| 113 | *Betula alnoides* Buch.-Ham. ex D.Don IBSD-SC/EPS/2016/IP/113 | *Saur* | Betulaceae | 14.28 | 0.09 | 0.14 | 1 | 2 | 7 | 1 | 9.09 | 2.74 |
| 114 | *Equisetum diffusum* D.Don. IBSD-SC/EPS/2016/IP/114 | *Kukarejhar, Aankhle Jhaar* | Equisetaceae | 12.5 | 0.09 | 0.125 | 1 | 1 | 8 | 1 | 9.09 | 1.37 |
| 115 | *Eupatorium adenophorum* Spreng. IBSD-SC/EPS/2016/IP/115 | *Kalijhar, Banmaara* | Asteraceae | 25 | 0.09 | 0.25 | 1 | 2 | 4 | 4 | 9.09 | 2.74 |
| 116 | *Melia azedarach* Linn. IBSD-SC/EPS/2016/IP/116 | *Bakaino, Persian liliac (Eng)* | Meliaceae | 20 | 0.09 | 0.2 | 1 | 5 | 5 | 6 | 9.09 | 6.85 |
| 117 | *Rhus chinensis* Mill. IBSD-SC/EPS/2016/IP/117 | *Bhakiamilo* | Anacardiaceae | 20 | 0.09 | 0.2 | 1 | 1 | 5 | 1 | 9.09 | 1.37 |
| 118 | *Rheum austral* D.Don. IBSD-SC/EPS/2016/IP/118 | *Mula, Laphup, Muli, Radish* | Polygonaceae | 9.09 | 0.09 | 0.09 | 1 | 4 | 11 | 9 | 9.09 | 5.48 |
| 119 | *Sonchus wightianus* DC. IBSD-SC/EPS/2016/IP/119 | *Ban rayo* | Asteraceae | 33.33 | 0.09 | 0.33 | 1 | 1 | 3 | 1 | 9.09 | 1.37 |
| 120 | *Zanthoxylum oxyphyllum* Edgew. IBSD-SC/EPS/2016/IP/120 | *Bhainsitimur* | Rutaceae | 25 | 0.09 | 0.25 | 1 | 1 | 4 | 1 | 9.09 | 1.37 |
| 121 | *Curcuma caesia* Roxb. IBSD-SC/EPS/2016/IP/121 | *Kalohardi* | Zingiberaceae | 28.57 | 0.181 | 0.28 | 2 | 5 | 7 | 9 | 18.18 | 6.85 |

**Abbreviations: FoC**- Frequency of Citation, **S**-Survey (primary data) and **R**- Reference (Secondary data /Published literature), **RFC**- Relative Frequency of Citation**, UV**- User Value, **FL** - Fidelity Level.

Fig. 2 — Traditional health care practitioners sharing their traditional knowledge with ethnopharmacological survey team of IBSD-Sikkim Centre, Gangtok: 1. Shri Kashi Ram Giri of Sang Nazitam, 2. Shri Karna Man Rai, Sama Ramiti, Upper Lingdum, 3. Shri Dwari Lal Rai, of Rolep, Lamaten, 4. Shri Narbir Rai of Upper Rolep, Malbasey, 5. Shri Durga Dhan Rai of Rolep Busty, 6. Shri Sonam Tamang of Rolep, arugotey, 7. Shri Kula Nanda Dkalh of Chujachen, Gangyep Busty, 8. Shri Bikash Rai of Dalapchen, Chandeney Busty, East Sikkim, 9. Shri Tika Ram Gurung of Upper Satam Busty, South Sikkim, 10. Shri Dadhi Ram Sharma of Namcheybong, Khonsey, Pakim, East Sikkim and 11. Shri Ratan Das Rana of Namli, Gidang, Near Smileland, Ranipool, East Sikkim and 12. Dr. Lokesh Deb and Dr. Sunil S. Thorat displaying the medicinal plant parts preserved by Shri Dwari Lal Rai.

formulations. A total of 121 plants belonging to 65 families have been considered in the present study.

***Frequency of Citation (FoC)***

The frequency of citation provides useful hints towards the use of more widespread plant species used by the informant and is ranging from 9.09–45.45% with average value of 13.37% (Table 1). Out of which *Kaempferia rotunda, Viscum articulatum and Berginia ciliata* (FoC=45.45%, respectively) were dominating followed by *Terminalia chebula* (FoC=36.36%) and *Swertia chirayita, Curcuma zedoaria, Phyllanthus emblica, Heracleum wallichii, Evodia fraxinifolia, Oroxylum indicum,* and *Fraxinus floribunda* (FoC=27.27% respectively). All the FoC values exhibited significant range[30-32]. From FoC calculations, the plant species having highest frequency of citation may provide useful insight for new chemical entities. While in reference plant species, the frequency of citation was found to be ranging from 0–24.66% with average value 0.6% (Table 1). Of which *Azardicta indica* (FoC=24.66%) dominated followed by *Terminia chebula, Centalla asiatica* and *Phyllanthus emblica* 23.29%, 21.92% and 19.18%, respectively. The bar plot for the frequency of citation for the survey and reference data depicted the variation in the use of species (Fig. 3). The graph further revealed fewer differences in FoC of *Psidium guajava, Calotropis gigantean, Rubia cordifolia, Mimosa pudica, Cuscuta reflexa, Cannabis sativa, Rhododendron arboreum, Nordostachyus jatamansi* and *Bombax ceiba*.

***FIV***

Family Importance Value (FIV) determines the species of a particular plant family and their use in the treatment of a specific disease[30]. From the Supplementary Table S3, it was found that the species from plant families Apiaces, Caesalpiniaceae, Rosaceae, Zingeberaceae have shown highest use by the native people (FIV=45.45) followed by Euphorbiaceae, Ranunculaceae, Rutaceae, (FIV=36.36) Anacardiaceae, Betulaceae, Lamiaceae and Lauraceae, Pinaceae, Poaceae and Rubiaceae (FIV=27.27). Abundance and availability of particular plant species are affecting the use of specific species by the importance. For instance, *Zingiber zerumbet* has broad pharmacological actions; some informants used the plant for anti-oxidant, anti-inflammatory disease treatment while others used it for treatment of other disease conditions[12,17].

***UV***

The user value (UV) determines relative importance of uses the plant species used by the informants [27, 28]. Table S1 provides UV values of plants used by the informants ranging from 0.083 – 1 with an average value 0.0716. Out of which maximum score UV= 1. All the UV values exhibited a significant range. The user values of the plant varied corresponding to the age and knowledge of informants[25,26]. Figure 4 is representing a bubble plot of RFC values and user value maximum data captured in the circle ensures the significance of plant use by the informants. The bubble plot further corroborated encircling maximum data in the significant range corresponding to species used by informants (Fig. 4). The Principal Component Analysis (PCA) calculation revealed a significant correlation between the relative frequency of citation and user values (Fig. 5).

***RFC***

RFC further provides useful hints on authentic plants used by the informants in the treatment of specific diseases in general. Table 1 provides RFC values of plants used by the informants ranging from 0.090–0.4545, with an average value of 0.133. Out of which *Kaempferia rotunda, Viscum articulatum* and *Berginia ciliata* (RFC=0.4545) were found to be dominating followed by *Terminalia chebula* (RFC=0.3636) and *Swertia chirayita, Curcuma zedoaria, Phyllanthus emblica, Heracleum wallichii, Evodia fraxinifolia, Oroxylum indicum,* and *Fraxinus floribunda* (RFC=0.2727). All the RFC values exhibited a significant range[30-32]. From RFC calculations, the plant species having the highest frequency of citation may provide useful insights for new chemical entities.

***ICF***

Calculation of ICF value was done by categorizing formulations used in various disease conditions, in other words, variability in the mode of utilization against disease. Total eleven categories of disease conditions were prepared and found gastrointestinal disorder with 76 use-reports, followed by body pain and respiratory (64 and 49 use-reports, respectively). This finding showed GI disorders and pain to be prevalent in the study area. ICF values ranged from 0.76 (general health) – 0.89 (gastrointestinal disorder). The average value of ICF for all categories was 0.87 and followed a significant range. The

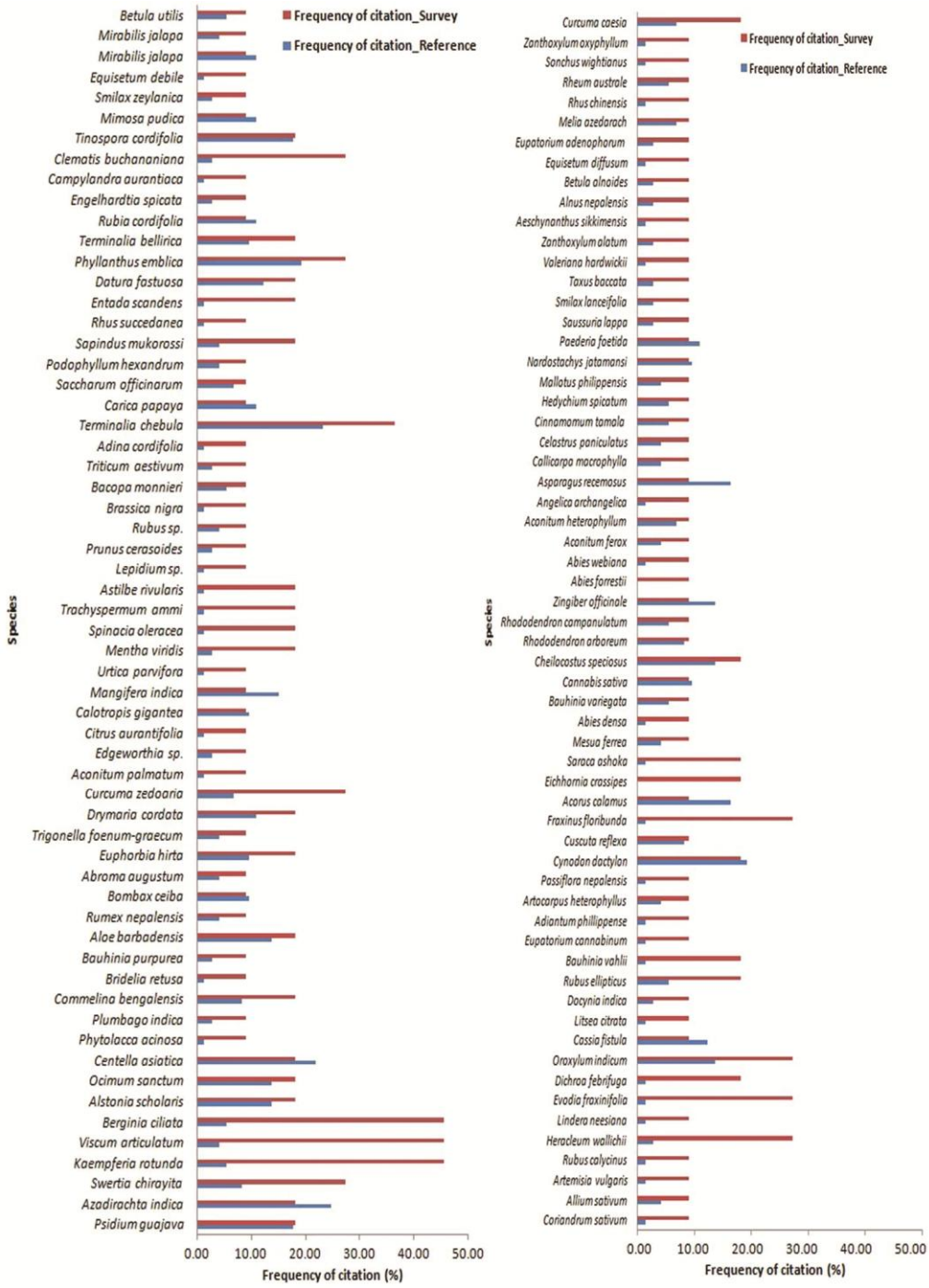


Fig. 3 — The bar plot for frequency of citation for survey and reference data clearly depict the variation in use of species

number of diseases treated by the informant and species used is shown in Figure 6 and in Supplementary Table S4.

## Discussion

A cross-cultural ethnopharmacological survey was carried out in East Sikkim and South Sikkim districts of Sikkim. The population of East Sikkim is 283,583 and South Sikkim is 146,850 out of 610,577 total population of Sikkim with a population density 86 per Sq. km., as per the population census 2011 report published by the Government of India. In the present study, initially area wise traditional healers were identified by the door-to-door survey according to the

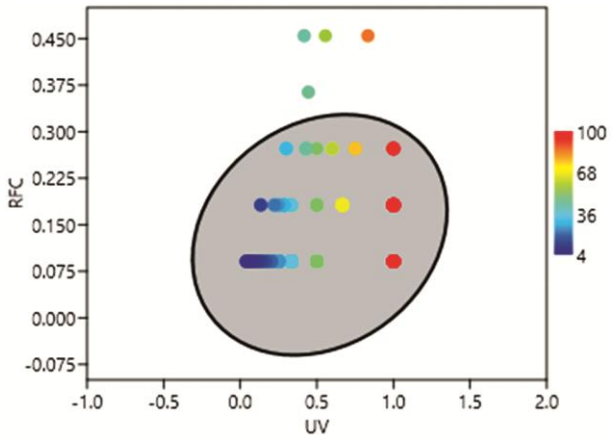


Fig. 4 — Bubble plot representing RFC and UV (maximum data set has shown significant zone and 95% of data coverage in circle).

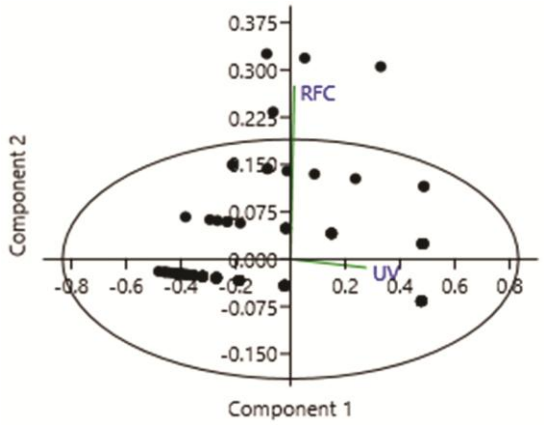


Fig. 5 — Principal Component Analysis representing the correlation among the Relative Frequency of Citation (RFC) and User Value (UV) of the species used by informant in ethnobotanical survey RFC (PC-1= 0.048844; PC-2 = 0.99881), UV (PC-1= 0.99881; PC-2= -0.048844).

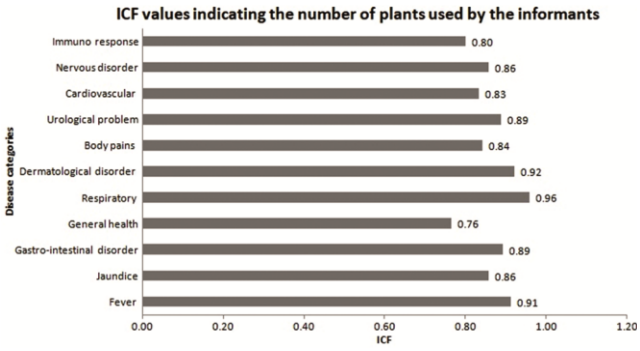


Fig. 6 — Informant Consensus Factor indicating the category wise use of plant species by informants for various diseases.

information guide published by Sikkim State Medicinal Plant Board, Government of Sikkim. Subsequently, the identified healers of respective areas were requested for sharing their traditional knowledge of traditional healthcare practices. However, out of 19 identified healers, only 11 healers agreed to share their traditional knowledge. The ritual bindings and fear of loss of livelihood dependent intellectual property were found as leading causes of rejection in sharing traditional knowledge. A predesigned questionnaire was used for interviews at the residence of respective folklore healers. Their patient handling and preparations of formulations were documented in written and audio-visual format. Hopefully, the results of scientific validation will proof/justify the traditional claim in the near future. So far, the IBSD has developed an anti-arthritic formula, out of this traditional knowledge collected and the same is now under phytochemical and preclinical trials (Unpublished data). In order to highlight the uniqueness of our findings, an extensive literature survey was carried out for searching the traditional use of documented ethnomedicinal plants reported from other parts of India as well as the world. The acquired information from a literature survey (secondary data) is compiled in Supplementary Table S5.

A total of 121 plants belonging to 65 families were found to be used as a component for 193 formulations. Graphical representation of the FoC, especially survey and reference data shown significant correlation indicating common and specific use of plants in the treatment of different diseases. The exciting variation observed from different indices highlighting species that need further attention for conservation and safeguarding the knowledge on traditional healthcare system. From the ethnobotanical survey, we found that herbal formulations are an integral part of the stakeholder of these resources[33]. From the descriptive data analysis, the highest cited plant by healer needs to be preserved due to overexploitation. Species once lost from nature means complete loss and have a negligible chance of recovery[12,16]. However, the knowledge of healing has been transferred from one generation to another and mostly by the non-codified method. Therefore, it's the prime responsibility of scientific fraternity to document such information before the loss. The use of a particular plant by specific community varies from region to region and subject to the knowledge of use by the informant on availability, cultivation practices, conservation status and alternative bioresources/plants[10]. The ICF is a determinant of the

homogeneity of ethnobotanical information. Natural bioresources are directly or indirectly accountable for the socio-economic, and religious aspect of livelihood of people of this region. Conserving bioresources is a prime responsibility of individuals and policymakers[34]. Prolonged use of modern medicines and limitations of synthetic chemistry will not only enable the use of alternative medicine but will also alleviate the burden on natural resources. The RFC values authenticates the frequency of citation of a medicinal plant used in various ailments.

The highest value of RFC provides a useful hint towards the user-specific family of plants by ethnic healers. FoC signifies the importance of particular plant species especially those indispensables in the daily commodity. Without those species, the use of local bioresources is an unfathomable task. For instance, bamboo, which is an inevitable part of the routine of North East India and accountable for more than 1500 varieties of uses from cradle to coffin, thus regarded as green gold. The medicinal importance of bamboo in digestive and seed for reproduction is well established across the region. The growth of a particular group of the plant depends on the soil type, temperature, water, agro-climatic conditions, rainfall, and tropical condition. More than eighty statistical indices are used for ethnobotanical research[33]. Some of them categories as per cultural, social aspects while other on Shannon-Weiner Index statistical calculations and are explained elsewhere for considering the specific significance of ethnobotanical data and their uses thereof[31,35]. The ethnobotany is the resource capital of the nation due to the broad scope of knowledge. ICF value indicates less consistency of the informant knowledge in the plants used for the treatment and lesser level of agreement among the informant on the use of a particular plant to treat disease condition.

Further, high ICF values always associated with a few plants that have high user citations for treating a specific disease category[16]. The high value of ICF is a good indicator of a high rate of information consensus[31]. Based on values obtained from FoC, RFC, UV, FL and FIV, it is implied that which species need immediate conservation priority. Natural bioresources are directly or indirectly accountable for the socio-economic, religious aspect of livelihood of people of this region. Conserving bioresources is a prime responsibility of individuals and policymakers. Prolonged use of modern medicines and limitations of synthetic chemistry not only enable to use of alternative medicine but also elevate the burden on natural resources.

The identification of bioresources and disease conditions as per signs and symptoms explained by the healers during the survey was the main limitation in this survey. However, the survey team comprising a pharmacologist, botanist, local language interpreter, has verified all documented information. For the verification of recorded information, survey team interacted with patients treated by respective folklore healers, as well as expert doctors and taxonomists. In this article, only authentically identified bioresources and disease conditions have been reported.

**Recommendations**

The following points are suggested to be taken up immediately by the authority for the protection and preservation of medicinal plants.

- ✓ Documentation of traditional healthcare practices of the communities should be given top priority to protect and preserve the rich traditional knowledge (TK) so that future plans can be taken up effectively by identifying the medicinal plants used by traditional healers.
- ✓ Work for assessment of TK related to the ethnomedicinal plants should also be taken up by using the services of the traditional healers and other stakeholders.
- ✓ Establishment of Medicinal Plants Garden in each district should be taken up in war footing by utilizing the services of traditional healers to identify the ethnomedicinal plants of the particular region.
- ✓ If possible, there should be Sub-Divisional Medicinal Plants Garden also by identifying the medicinal plants used by the stakeholder in such micro-climatic conditions of the area within the district.
- ✓ Home Herbal Garden should also be established for popularizing the medicinal plants and useful application of them to treat the primary health condition of the people.
- ✓ Documentation of traditional veterinary practice of the community should also be taken up.
- ✓ Training of the traditional healthcare practitioners in the village level on the preparation of herbarium, scientific collection, and storage of bioresources for sustainable utilization.

- ✓ People's Biodiversity Registrar (PBR) work should also be completed in the state.
- ✓ Individual stakeholders of medicinal plants should be given moral and financial support.
- ✓ To establish a market for selling medicinal plants and its products in all sub-divisional areas and district headquarters.
- ✓ To establish a processing unit for ethnopharmacological products.
- ✓ To lease out about 10 hectares of forest land for five years, if possible, to the traditional healers for the cultivation of medicinal plants on an experimental basis. Continuation of the same and extension of lease duration to the successful implementing individuals.
- ✓ To organize an awareness program about the use of traditional knowledge in the healthcare system.
- ✓ To establish clubs for plantation and preservation of medicinal plants in schools and colleges.
- ✓ To take up scientific research work on medicinal plants, traditional formulations and application of ethnomedicinal plants' products in the healthcare system.

## Conclusion

This study provides an array of rich indigenous knowledge on folklore healthcare practices and the therapeutic potential of the bioresources used by local healers of Sikkim. These plants are sources of useful therapeutic agent(s) and also sources for the discovery of many bioactive principles. The natural bioresources are an integral part of ethnomedicine. Maximum informants use those resources for the treatment of some common and uncommon disease conditions. The scientific validation of the claims made so far by the ethnic healers is need of an hour to extend broader scope and acceptability of this system of healthcare. The study highlights the immediate need for documentation of vital knowledge before the loss. The metadata from these findings will be useful for policymakers to formulate an appropriate strategy for conservation and sustainable use of bioresources. The Quantitative estimation for survey data has been gaining wider acceptability due to relative importance by the research fraternity. The descriptive statistical method used in this study for the evaluation of FoC, ICF and FIV provides useful insight on species, plant, or formulation used by the healers. FoC elaborates on shared information on species. ICF signifies the homogeneity of data. FIV depicts a particular family of species used by the informants.

## Supplementary Data

Supplementary data associated with this article is available in the electronic form at http://nopr.niscair.res.in/jinfo/ijtk/IJTK_20(04)(2021)965-981_SupplData.pdf

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## Conflict of Interest

The authors declare that they have no conflict interests.

## Authors' Contributions

**MM** participated in Ethnopharmacological Survey, recorded traditional knowledge, compiled survey data, prepared tables, and helps in written the Manuscript. **BG** helped in literature survey, preparing tables and corrected manuscript. **BGS-** designed, statistically analyzed survey data and prepared Bubble plots, PCA correlation graphs etc. and critically reviewed the manuscript. **SST** acts as a state coordinator for conducting ethnopharmacological survey in two districts of the Sikkim state. He critically reviewed all compiled survey data and overall Manuscript. **BR** participated in ethnopharmacological survey, interpreted local languages into English, recorded traditional knowledge, compiled survey data, and prepared tables. **PK** participated in ethnopharmacological survey, found out traditional healers in the locality, recorded traditional knowledge and interpreted local languages into Hindi. **LD** acts as a Team Leader for this ethnopharmacological research. He has designed overall project, prepared questioners and data sheet. He organized/conducted survey in coordination with supporting staffs,

mentored overall documentation process, done video-graphic documentation, developed data compilation methods, analyzed all survey data. He also wrote the manuscript, compiled figures and tables with help of the team members and communicated the Manuscript.

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