



People and plant: Learning with *Adi* community on ethnomedicinal practices and conservation in Arunachal Pradesh, India

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Local plant species have been in use in variety of ethnomedicinal practices from the time immemorial among the people of various communities for treating various human diseases. This paper reports about the plant species used by *Adi* community in curing various human diseases and ailments. A study was conducted during 2008-2009 and further refined in succeeding years with the 12 purposively selected traditional knowledge holders (TKHs) of *Adi* tribe of East Siang district, Arunachal Pradesh, India. Data were collected using combined approaches of personal interview, participant observations and transect walks. It was observed that with Shannon-Weaver diversity index 2.73, there were 39 local plant species belonging to 25 plant families and used as ethnomedicinal practices by the TKHs. Most of the species (17) were used by *Adi* TKHs with their green leaf parts followed by root and fruits (5 each) to develop ethnomedicinal formulations. Out of these, several species namely *Leucas aspera* (Willd.) Link.; *Plumeria rubra* L.; *Catharanthus roseus* (L.) G. Don; *Solanum torvum* Swartz; *Solanum khasianum* C.B. Clarke; *Oroxylum indicum* (L.) Benth.ex Kurze; and *Tinospora cordifolia* (Thunb.) Miers) were found in use by *Adis* against asthma, bronchitis, cough, sinusitis, diabetes, malaria, typhoid and jaundice. The *Adi* TKHs maintain a rich cultural ethics, govern by their own world-view in continuing ethnomedicinal practices, and harvesting the species from various land use systems with the aim to sustain biodiversity and associated practices. The key findings indicated that, plant species used as ethnomedicines for some of the diseases and ailments by the *Adi* TKHs, can be undertaken for the long-term trial to find some natural remedies against few human diseases, including search of immune enhancer against COVID-19, provided TKHs of *Adi* community are partnered in ethically and culturally appropriate manner.

Keywords: *Adi* tribe, Arunachal Pradesh, Conservation, COVID-19, Cultural ethics, Ethnomedicinal plant species, Human health, Traditional knowledge holders

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The indigenous and tribal people over the world have learned and evolved traditional knowledge about how to live and sustain their life in fragile and remote ecosystems^{1,2}. These communities have their special world-view about the plants they derive for use as food, ethnomedicines and other needs³. It is estimated that about 150 million indigenous people are living in Asia¹, and traditional knowledge of such people have played a critical role in assigning cultural and commercial values to the local plant species, and also evolving eco-friendly conservation and management strategies⁴. The unique feature of such communities is

that, despite people are poor in material wealth, they are rich in biodiversity related knowledge and ecological ethics required to maintain biodiversity and ecosystem services^{3,5}. Such knowledge are unique in the sense that they are intricately linked with their cultural realm and indigenous institutions, and has been instrumental in shaping local biodiversity, livelihood systems and cultural landscapes^{3,5,6}. In many indigenous and tribal communities, traditional usage of local plants in ethnomedicines and foods has provided immediate and cost effective solutions for food and health security⁹. World-wide, local plant species used in ethnomedicines are recognized to be a valuable source for new drugs⁷. It is also assessed that about 80% of people of developing world use

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these species as primary remedies against a number of health issues^{8,9}.

In India, North-Eastern regions are recognized as one of the biodiversity hot spots¹⁰. Mafi (2010)⁶ mapped India as one of 25th top centers of biocultural diversity in which Indo-Myanmar border (the Northeastern region share borders with it) is recognized one of the major one. In Arunachal Pradesh, a wide range of plant biodiversity, portrayed by cultural diversity, makes the state unique³. The local communities of the state, living in fragile ecosystems, have developed location specific knowledge to meet out their daily food, ethnomedicines and other livelihood needs including cultural practices³. Such traditional knowledge is nurtured by indigenous institutions, and that have enabled communities to conserve local biodiversity having crucial ecological significance.

Looking to the importance of traditional knowledge of tribal communities, the objectives of this study was (i) to explore the ethnomedicinal practices of *Adi* tribe of Arunachal Pradesh which they apply in treating and curing various diseases and ailments, and (ii) to illustrate the socio-cultural, ecological and diversity dimensions of the local plant species being used.

Research methodology

Sampling of area and respondents

The Northeastern region of India can be physiographically divided into the eastern Himalayas, the northeastern hills and the Brahmaputra and Barak valley plains. This region occupies 262,179 square kilometers area with a population of 45.773 million. The immense biodiversity of the region has made it priority area for investment by the leading conservation agencies. The richness of the region's biodiversity largely reflects the diversity of habitats associated with a wide altitudinal range. Among the Northeastern regions of India, Arunachal Pradesh is well-known for its biocultural diversity spread among 28 tribes and about 110 ethnic communities in 25 administrative districts. The population of Arunachal Pradesh is ~ 13.84 million (2011 census), and out of this, ~ 60 % are scheduled tribes. For the present study, Arunachal Pradesh state was chosen purposely based on the ethnicity and heavy dependence of its local communities on plant resources for their health management and livelihood needs. The East Siang district was further chosen purposely following the similar criteria as in state

selection. The key traditional healers and Traditional Knowledge Holders (TKHs) were explored using snowball sampling technique. Thus, a total of 12 knowledge holders were chosen for this study.

Method of data collection and analysis

Study was carried out during 2008-2009 and further refined in succeeding years in online collaborative mode with the leading TKHs. Data was collected using combination of personal interview, and participant observations with the selected TKHs. The information on ethnomedicinal plants obtained from at least two knowledge holders were only kept for analysis. Personal interview was conducted using unstructured schedule with TKHs and data were recorded in the qualitative forms so that deeper meaning and narrations can be explained. Transect walks were also made to verify some selected plant species being used in ethnomedicines by these knowledge holders. The taxonomic identification of collected plants used in a particular ethnomedicine was made possible with the help of Regional Office of Botanical Survey of India (BSI), Itanagar, Arunachal Pradesh. As per the CBD (Convention on Biological Diversity (2000))^{11,12} norms, at the time of interviewing knowledge holders, the knowledge holders were explained the aim of study and probable outcomes in terms of hard and digital forms of publications. The oral consent of knowledge holders was obtained to disclose their knowledge, as they were interested to bring their ethnomedicinal knowledge to rest of the world (particularly in India). This was further aimed to create awareness among other stakeholders in order to promote learning and conservation practices, unless reported practices are not going to be used at commercial scale by third party. One of such leading knowledge holders (YJL) was undertaken as co-author in this article to maintain ethics of knowledge shared by them. Data were entered into spread sheet and analyzed thematically using descriptive statistics. The diversity of plant species was calculated using PAST software (version 4, 2020)¹³.

Results

Plant species, their habits and parts used as ethnomedicinal practices

The results indicated that 39 plant species are being applied by *Adi* TKHs for making various ethnomedicinal formulations in treating diseases and disorders (Table 1). Photographic examples for few of these species are given in Figure 1. Out of 39, 14 species are herbs followed by shrubs (10 species),

Table 1 — Local plant species used by *Adi* community for treating and curing various diseases and ailments

Sr. N.	Local Name	Botanical name	Family	Habit	Conservation habitats	Parts used	Diseases/ailments
1	<i>Abok</i>	<i>Calotropis procera</i> (Aiton) W.T. Aiton	Apocynaceae	Shrub	<i>Morang</i> forest & <i>Jhum</i> lands	Roots	Typhoid & jaundice
2	<i>Bangko</i>	<i>Solanum spirale</i> Roxb.	Solanaceae	Shrub	Home garden and <i>Jhum</i> land	Root and green leaves	High blood pressure, diabetes, malaria, typhoid & jaundice
3	<i>Bengi</i>	<i>Cassia siamea</i> Lam.	Fabaceae	Tree	<i>Morang</i> forest	Green leaves	As energy food in boiled form
4	<i>Dangal-Engin</i>	<i>Smilax perfoliata</i> Lour.	Smilacaceae	Climbing shrub	<i>Morang</i> forest & <i>jhum</i> lands	Tender stem and leaves	Fracture
5	<i>Dhuvephool</i>	<i>Catharanthus roseus</i> (L.) G. Don.	Apocynaceae	Herb	<i>Jhum</i> lands	Green leaves	Diabetes and malaria
6	<i>Dikang</i>	<i>Gymnocladus burmanicus</i> C. E. Parkinson	Fabaceae	Tree	<i>Morang</i> forest	Fruits	Dermatological disorders
7	<i>Dilap</i>	<i>Allium hookerii</i> Thw.	Liliaceae	Herb	Home garden & <i>Jhum</i> lands	Bulb and stem	High blood pressure and dysentery
8	<i>Domir-ekung</i>	<i>Oroxylum indicum</i> (L.) Benth.exKurze	Bignoniaceae	Tree	<i>Morang</i> forest	Bark	Typhoid & jaundice
9	<i>Ekisipyak</i>	<i>Leucas aspera</i> (Willd.) Link.	Lamiaceae	Herb	<i>Jhum</i> lands	Leaf	Asthma, bronchitis, cough & sinusitis
10	<i>Mita-miti</i>	<i>Scoparia dulcis</i> L. Spreng	Scropulariaceae	Herb	Home garden & <i>Jhum</i> lands	Leaf	Snake bites, itching sinus, cough & cold
11	<i>Eraapat</i>	<i>Ricinus communis</i> L.	Euphorbiaceae	Shrub	<i>Jhum</i> lands & <i>Morang</i> forest	Green leaves	Jaundice
12	<i>Gulachin</i>	<i>Plumeria rubra</i> L.	Apocynaceae	Tree	<i>Morang</i> forest	Flower	Asthma, bronchitis, cough, sinusitis, cough & bronchitis
13	<i>Hewali</i>	<i>Nyctanthes arbor-tristis</i> L.	Oleaceae	Shrub	<i>Jhum</i> lands	Green leaves	Malaria
14	<i>Hinger</i>	<i>Aristolochia indica</i> L.	Aristolochiaceae	Climber	<i>Morang</i> forest & <i>Jhum</i> lands	Whole plants	Snake bites and skin disease
15	<i>Katbu</i>	<i>Scoparia dulcis</i> L.	Scrophulariaceae	Herb	<i>Jhum</i> lands & home gardens	Green leaf	Fever and cough & boil
16	<i>Kekir</i>	<i>Zingiber siangensis</i> Rosc.	Zingiberaceae	Herb	Home garden & <i>Jhum</i> lands	Rhizome	Snake bite, dysentery, cough, fever, typhoid & jaundice
17	<i>Kiling-kiro</i>	<i>Centella asiatica</i> (L.) Urban	Apiaceae	Herb	<i>Morang</i> forest & <i>Jhum</i> lands	Whole plant	Asthma, bronchitis, cough, sinusitis, typhoid & jaundice
18	<i>Koppi</i>	<i>Solanum torvum</i> Swartz	Solanaceae	Shrub	Home gardens	Fruits	Diabetes & malaria
19	<i>Koppir</i>	<i>Solanum khasianum</i> C. B. Clark	Solanaceae	Shrub	Home gardens	Fruits	Diabetes & malaria
20	<i>Kynie-rimang</i>	<i>Tinospora cordifolia</i> (Thunb.) Miers	Menispermaceae	Climber	<i>Morang</i> forest	Stem	Typhoid & jaundice
21	<i>Marshang</i>	<i>Spilanthes oleracea</i> L.	Asteraceae	Herb	Home garden & <i>Jhum</i> lands	Fruit and leaf	Asthma, bronchitis, cough & sinusitis
22	<i>Mip-hit-loom</i>	<i>Piper nigrum</i> L.	Piperaceae	Climber	<i>Jhum</i> lands & home garden	Fruit	Asthma, bronchitis, cough & sinusitis
23	<i>Namiperi</i>	<i>Artemisia nilagirica</i> (C.B. Clark)	Asteraceae	Herb	Home gardens	Green leaves	Malaria
24	<i>Nemar</i>	<i>Piper mullesua</i> D. Don.	Piperaceae	Shrub	<i>Jhum</i> lands & home gardens	Leaves and fruits	Malaria

(Contd.)

Table 1— Local plant species used by *Adi* community for treating and curing various diseases and ailments

Sr. N.	Local Name	Botanical name	Family	Habit	Conservation habitats	Parts used	Diseases/ailments
25	<i>Nevi-nelum</i>	<i>Kalanchoe pinnata</i>	Crassulaceae	Herb	<i>Jhum</i> lands	Green leaves	Burn
26	<i>Nung-Boko</i>	<i>Moringa oleifera</i> Lam.	Moringaceae	Tree	Home garden	Bark	Malaria, typhoid & jaundice
27	<i>Nwrshing</i>	<i>Murraya koenigii</i> (L.) Sprengel	Rutaceae	Tree	Home garden & <i>Jhum</i> lands	Leaf	Asthma, bronchitis, cough & sinusitis
28	<i>Ogjok</i>	<i>Bauhinia variegata</i> L.	Caesalpiniaceae	Shrub	<i>Jhum</i> lands & home garden	Green buds, leaves and flowers	For sick person as food, dysentery and piles
29	<i>Onger</i>	<i>Zanthoxylum rhetsa</i> DC	Rutaceae	Shrub	Home garden	Green leaves	Jaundice and avoiding tapeworm infection
30	<i>Ongin</i>	<i>Clerodendrum colebrookianum</i> Walp.	Lamiaceae	Shrub	Home garden	Leaf	Malaria, high blood pressure and diabetes
31	<i>Papaya</i>	<i>Carica papaya</i> L.	Caricaceae	Tree	Home garden	Root	Malaria, typhoid & jaundice
32	<i>Peeli</i>	<i>Piper longum</i> L.	Piperaceae	Climber	<i>Jhum</i> lands & <i>Morang</i> forest	Green leaves	Cough and constipation
33	<i>Ringko</i>	<i>Coptisteeta</i> Wallich	Ranunculaceae	Herb	<i>Morang</i> forest & <i>jhum</i> lands	Root	Tonic, gastric trouble, headache, malaria, typhoid & jaundice
34	<i>Singer</i>	<i>Alstonia scholaris</i> R. Br.	Apocynaceae	Tree	<i>Morang</i> forest & <i>jhum</i> lands	Green leaves	Diabetes, malaria, diarrhoea, typhoid & jaundice
35	<i>Tami</i>	<i>Eleusine coracana</i> Gaertn.	Poaceae	Herb	<i>Jhum</i> lands & home garden	Grain	Local beer made from seeds and given in cold, congestion and neutralizing wine
36	<i>Tamin</i>	<i>Rubia cordifolia</i> L.	Rubiaceae	Climber	<i>Jhum</i> lands & <i>Morang</i> forest	Root	Cold and cough, headache
37	<i>Tayer</i>	<i>Litsea cubeba</i> (Lour.) Pers.	Lauraceae	Tree	<i>Morang</i> forest & <i>Jhum</i> lands	Leaves and fruits	Blood dysentery, stomach trouble & fever
38	<i>Telimbabo</i>	<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	Asteraceae	Herb	<i>Morang</i> forest	Green leaves	Headache and fever
39	<i>Yepetare</i>	<i>Paederia foetida</i> L.	Rubiaceae	Herb	Home garden	Leaf	Typhoid & jaundice



Fig. 1 — List of local plants species used in ethnomedicinal formulations (see details of usage in Table 1)

A=*Nemar* (*Piper mullesua*); B=*Dilap* (*Allium hookerii*); C=*Hinger* (*Aristolochia indica*); D=*Ongin* (*Clerodendrum colebrookianum*); E=*Dikang* (*Gymnocladus burmanicus*); F= *Kiling-Kiro* (*Centella asiatica*); G=*Bangko* (*Solanum spirale*); H= *Onger* (*Zanthoxylum rhetsa*)

trees (9 species), climbers (5 species) and climbing shrub (1 species) (Table 1). The highest number of species being applied by healers/ knowledge holders in treating/curing various diseases and ailments belong to the plant family *Apocynaceae* (4 species), followed by *Asteraceae* (3 species), *Lamiaceae* (3 species), *Piperaceae* (3 species) and *Solanaceae* (3 species) (Fig. 2). Two species each from *Fabaceae*, *Rubiaceae* and *Rutaceae* are used as ethnomedicine in curing various diseases and ailments. There were 17 other plant families from which single species were used for the health issues. The highest number of plant species (17) were used for their green leaves followed by root (5 species) and fruits (5 species) to develop different formulations and applied in treatment of diseases and ailments (Fig. 3). While in 2 species, the bark, stem and whole plants are used as ethnomedicines against various diseases and ailments. Bulbs, flowers and grains were least used parts for different health issues. Observations revealed that highest number of species (6) were utilized in treating more than one diseases i.e., asthma, cold, cough and sinusitis, while 4 species are in use for treating typhoid and jaundice (Fig. 4). Similar number of species was

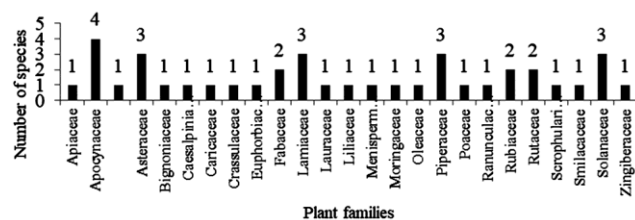


Fig. 2 — Number of plant species used in treating and curing diseases/ailments from different plant families

found in use for treating diabetes and malaria together, while for malaria alone, TKHs were using 3 plant species. A total of 20 plant species were found to be applied individually as ethnomedicinal formulations for curing either one or more than one diseases/ailments.

Many of the TKHs reported that they have learnt ethnomedicinal knowledge from their elders. For example, one of the key healers Mrs. Yanung Jamoh Lego (55 yrs), who is a well-recognized ethnomedicinal practitioner (Fig. 5) reported that her mother was a healer of vein related issues while father is a highly culturally rich person in preserving bioresources. These TKHs are morally rich, and they do not take any fixed fee for their healing practices. For example, YJL takes her fee depending on types of patients and their paying capacity. Generally from the poor patients, she does not take any fee. To signify her moral in taking fee for healing practices, she narrated:

"I take nominal fee from patients only to meet out the expenditure to be incurred for the labour"

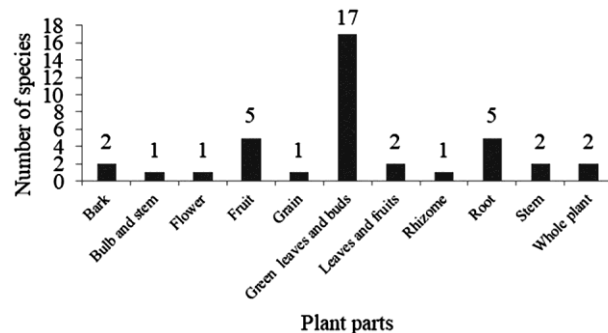


Fig. 3 — Different plant parts from species being used in treating and curing diseases/ ailments

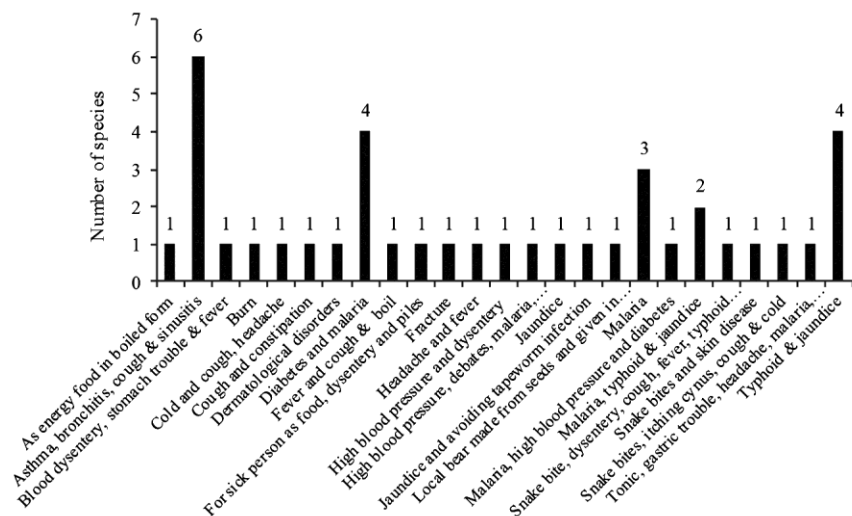


Fig. 4 — Types of diseases/ailments and number of plant species used for treatment/cure



Fig. 5 — Mrs. Y. J. Lego: A traditional healer (Photo: Ranjay K. Singh)

engaged in preparing ethnomedicines, and collection of plants from far flung forests where travel is difficult”.

The TKHs have created their knowledge network to exchange knowledge and practices on local plants they use in healing or treating diseases and ailments. For example, YJ Lego has started creating her network by involving ~20 healers and other knowledgeable persons including women, to learn and promote ethnomedicinal practices. These knowledge holders believe that this network helps in creating awareness about the importance of local plants in curing the human disease, and assigning traditional values to them.

Mythology and cultural ethics in plants use and their conservation

It was learnt that, as per *Adi* mythology, plants are emanated from the body of different supreme Gods and Goddesses. For example, the wild jackfruit (seeds, bark, flowers and immature fruits are given in tuberculosis by some healers) originated from the breast of goddess *Kini Nane* (Goddess of agriculture and forest resources), while *Centella asiatica* was derived from the small intestines of *Sedi* (the creator

of earth) and *Ripik* (a climber) from the dandruff of *Totik* (the supreme devil). Similarly, the *kekir* (*Zingiber siangensis*) and *ridin* (a climber) are empowered by the god to keep away most of the evil spirits, and keep human healthy. Therefore, these TKHs consider local plant species as an immediate part of the supreme power (nature), and as such there is no plant on earth which is devoid of medicinal values. Apart from this, the air, the water the life giving elements comes from the plants, and they are treated as holy living things, as perceived by TKHs. So, before taking any part from a plant, prayer is obligatory because TKHs consider that these plants hear their pledges and bestow their power for healing of patients. TKHs reported that their forefathers used to say that power of healing comes from nature and not from any physician. Physicians are only selected as mediators in between the God and mankind to convey the messages of love, care to other voiceless creatures on earth. Mankind is considered as most intelligent creature of God on earth, and they are made to protect and safeguard the rest of the creatures, as perceived by TKHs. The TKHs stated that intuition, dream, mythological belief and folktales are major drivers that help in selecting a particular plant species for ethnomedicinal purpose. These TKHs follow certain ecological criteria while collecting plants from forest and locality to be used in curing various diseases. One of such TKHs stated that:

“It is always better to collect the plants for ethnomedicine from their original habitat (in-situ place), because using the same plant from modified landscapes has less efficacy over diseases” (YJL).

The TKHs also follow some beliefs while collecting plants. For example, during the menstruation cycle, a woman should not plug the plant. Similarly, during the full-moon lunar cycle, harvesting of plant should be avoided. It was learnt that, leading TKHs follow some spiritual acts before plucking a plant from the forest. They offer *kekir*, *apong* (fermented rice beverage) and boiled eggs to the forest deity in order to please her/him and wish to have the scope of collecting plants next time too. Only the required plant parts are harvested, and they believe that injudicious harvesting of plants leads to the death of concerned person. Further, felling of any flower and fruit bearing plant/tree species result in infertility of the respective person. To signify the ethics of sustainable harvesting of plant resources, a leading TKH stated as:

“God has created everything for all the living beings for their judicious use with love and care, but unfortunately the human have developed the habit of overexploiting plants to meet out their greed, and thus have destroyed the nature” (YJL).

Refinement in ethnomedicinal practices, and immune booster

With changing nature of diseases, the TKHs have made refinements in their ethnomedicinal practices. For example, about 10 years back to cure malaria, typhoid and jaundice, the powder of leaves of *singer* (*Alstonia scholaris*), bark of drumstick (*Moringa oleifera*), root of *nemar* (*Piper mullesua*) and local black pepper fruits were used frequently. Now looking to the increasing severity of these diseases, some TKHs have refined their formulations (Fig. 6). Now they add *Tinospora cordifolia*, *Leucas aspera*, *kekir* (*Zingiber siangensis*), *idu* (*Curcuma longa*) and *domir etkum* (*Oroxylum indicum*) as vitamin component in malaria. *Acorus calamus* and *mani-mooni* (*Centella asiatica*) are also added to enhance the efficacy of treatment. In recent past, some TKHs have added *oram bangin* (*Costus igneus*) also as part of other ethnomedicines to those patients who suffer from diabetes. In order to enhance the immune system of patients who suffer from malaria, cough, cold and similar other diseases, some of TKHs have developed a mixture of several local species e.g. *angyat* (*Coixlacryma-jobi*); *ayak* (*Setaria italica*); *Adi bean* (*Phaseolus vulgaris*); *mati-kolai daal* (*Macrotyloma uniflorum*); *mirung* (*Eleusine coracana*); *namdung* (*Perilla ocymoides*) and *peron-namsing* (*Glycine max*), etc., and is given in the powder form. This was stated by the TKHs that



Fig. 6 — Mrs. Y. J. Lego describing about a local plant used in refining ethnomedicinal practices (Photo: Ranjay K. Singh)

ethnomedicines need well integration with the healthy food systems in which this powder plays important roles. TKHs believe that, initially treatments of diseases through ethnomedicines aggravate the conditions of patient for few days, which is considered as a good sign for recovery. But, if it reacts otherwise that indicates some rituals have to be observed by the concern patient, and then followed by usual herbal course of treatments. These TKHs assign paramount importance to human health, and treat it accordingly. One of the leading TKHs narrated the meaning of human health in following way:

‘Health is wealth: As saying goes by many people, but practiced by only few. Many people hardly take care of their health; they cannot restrain themselves from the temptations of modern day appalling fast foods, luxurious life style and poor physical work. This results in a number of diseases and disorders’ (YJL).

Conservation and diversity of ethnomedicinal plant species

Observations revealed that most of the plant species used in ethnomedicines finds their place of conservation in three land use systems: *morang* (community forest), *jhum* lands and home gardens (Table 1). They are naturally grown and sometimes intentionally reared. The conservation of these species are influenced by the types of agricultural and livelihood activities in each of the land use systems. There is also a probability that some of these species may be found in other habitats like river bank, waste lands and roadside from where they are collected. The Shannon-Weaver indices indicated that with species richness 39, the plant diversity (H) across the species used for various diseases/ailment was found to be 2.73, while Simpson value was 0.96 and evenness (e^H/S) 0.59 (Fig.7).

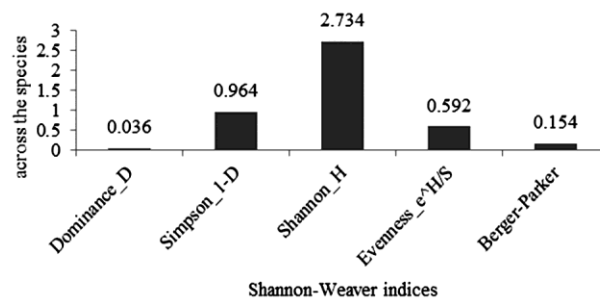


Fig. 7 — Shannon-Weaver indices across the plant species applied in treatment/cure across the diseases/ailments

Discussion

The key results indicated that local plant species play crucial role in treating a number of diseases and ailments among *Adi* community. Plants and culture are intricately linked, and the mythology of community plays significant role in selecting species for developing ethnomedicinal formulations. Earlier study also revealed that many traditional healers follow dream and some other myths for generating knowledge and practicing with local plant species for the healthcare¹⁴. The inclusive thinking of TKHs about plants used in ethnomedicines might be governed by their existing worldview, cultural practices and living in the remote locations where access of modern drugs and other resources required for human health are limited. Close interactions of TKHs with plant resources and local ecology have enabled them to develop local knowledge to be applied in healthcare practices. Interestingly, the plant species used in ethnomedicines are many times part of their food systems also (lest reported here)³. The local products developed from local species and used along with ethnomedicines may presumably improve overall health and immune system of *Adi* people. Such integrative practices provide new insights to develop longer strategies of research and development in fighting against the COVID-19 threat where immune system is considered to be a prime concern. Majority of the species used in ethnomedicines are used for their green leaf, roots and fruit parts to cure diseases, as reported earlier¹⁵. The TKHs, who use various parts of plants as ethnomedicines, are based on the years of informal experimentation using taste and efficacy as two major indicators³.

An appreciable diversity index (2.27) was observed across the species for treating number of diseases and ailments. This provided the insights that range of species selection by *Adi* TKHs for maintaining the health is wide, and they do not stick only with few species³. Most of the species were recorded to be conserved in the three land use systems: *morang forest* (managed collectively), home gardens (managed individually or sometimes shared between two) and *jhum* lands (managed individually or in between two or even more land owners) where species of ethnomedicinal significance may find for survival. Therefore, the land use system have considerable role in *Adi* community to sustain ecosystem and its provisioning services in terms of plant species used not only as ethnomedicines, but

also for the other livelihood means⁵. The cultural ethics and personal interest of TKHs were found to be major drivers in learning and continuing the ethnomedicinal practices. Such attributes of TKHs moderate human behavior for sustainable use of plant resources, evolving distinct cultures and management strategies to improve people-plant relations^{16,17}.

Conclusion

Our study indicated that leading traditional knowledge holders of *Adi* community use 39 local plant species as ethnomedicines for treating and curing various diseases and ailments. Many of these species are part of *Adi*'s food also. Thus, the food and ethnomedicinal practices have strong bindings to improve healthcare of *Adi*. Most of the species are used in form of green leaves and roots, and the ethnomedicinal knowledge is evolved from *Adi*'s own word-view. A range of plant species are used in curing more than one disease or ailment. These practices, in which plants play central role, are evolved among *Adis* from their trial-error practices. The close biddings of culture and nature have made such knowledge of *Adi* people unique and provide insights for inclusive thoughts on people-plant-ecology relations. The reported species are either naturally or intentionally reared and conserved in different traditional land use systems using local ecological knowledge. As it was found that TKHs also make some local product using plant species to be given to the patients along with ethnomedicines as immune enhancer, this could provide the insights on how such integrative practices can be undertaken in research and policy on developing strategies to fight the diseases like COVID-19. In addition to it, some of the ethnomedicinal formulations used by *Adis* can provide lead through the long-term trial for some of the other diseases and ailments reported here. However, to make it happen, a partnership will be required with *Adis* to share their knowledge and convert them into products in culturally and ethically appropriate manner as per the laws and rules of Government of India.

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Conflict of interest

Authors declare there is no conflict of interest on this article.

Authors' Contribution Statement

RKS and AKS designed and conducted the study. Being TK holder, YJL helped in data collection, networking with other knowledge holders for their sampling and provided inputs on plant based practices. RCS contributed in taxonomic explanation of plant species and BNH added intellectual contents to improve framework and discussion of paper. All the authors read and approved the articles.

References

- Rai R & Nath V, The role of ethnic and indigenous people of India and their culture in the conservation of biodiversity, Paper presented in XII World Forestry Congress, 2003, <http://www.fao.org/3/xii/0186-a1.htm#fn1>. (Accessed April 2020).
- Hussain W, Badshah L, Ullah M, *et al.*, Quantitative study of medicinal plants used by the communities residing in Koh-e-Safaid Range, northern Pakistani Afghan borders, *J Ethnobiol Ethnomed*, 14 (2018), 30. <https://doi.org/10.1186/s13002-018-0229-4>.
- Singh R K, Hussain S M, Riba T, *et al.*, Classification and management of community forests in Indian Eastern Himalayas: implications on ecosystem services, conservation and livelihoods, *Ecol Proc*, 27 (2018). <https://doi.org/10.1186/s13717-018-0137-5>.
- Dunn C P, in *Climate change and its consequences for cultural and language endangerment*, by K L Rehg, L Campbell (The Oxford Handbook of Endangered Languages), 2018, p. 720-738.
- Singh R K, Kumar A, Singh A, *et al.*, Evidence that cultural food practices of *Adi* women in Arunachal Pradesh, India, improve social-ecological resilience: Insights for sustainable development goals, *Ecol Proc*, 9 (2020) 29. <https://doi.org/10.1186/s13717-020-00232-x>.
- Maffi L, What is biocultural diversity? In *Biocultural Diversity Conservation: A Global Source Book* by L Maffi & E Woodley (Earthscan, London), 2010, 1-11.
- Chen S L, Yu H, Luo H M, *et al.*, Conservation and sustainable use of medicinal plants: problems, progress, and prospects, *Chinese Med*, 11 (2016) 37. doi: 10.1186/s13020-016-0108-7.
- Hamilton A C, Medicinal plants, conservation and livelihoods, *Biod Cons*, 13 (2014) 1477–1517. doi: 10.1023/B:BIOC.0000021333.23413.42.
- Souza E N F, Williamson E M & Hawkins J A, Which plants used in ethnomedicine are characterized? Phylogenetic patterns in traditional use related to research effort, *Front Plant Sci*, 9 (2018) 834. doi: 10.3389/fpls.2018.00834.
- ENVIS, Global biodiversity hotspots with special emphasis on Indian hotspots: Biodiversity hotspots in India, ENVIS Centre on Floral Diversity, 2011. http://www.bsienviis.nic.in/Database/Biodiversity-Hotspots-in-India_20500.aspx. (Accessed May 2020).
- Laird S A, Biodiversity and traditional knowledge: Equitable partnership in practice (Earthscan Publication, London, UK), 2012, 7-11.
- Hansen S A & Van-Fleet J W, Traditional knowledge and Intellectual Property, A Handbook on Issues and Options for Traditional Knowledge Holders in protecting their Intellectual Property and Maintaining Biological Diversity, (American Association for the Advancement of Science (AAAS), Washington, D.C.), 2003, 3-53. <https://community-wealth.org/sites/clone.community-wealth.org/files/downloads/book-hansen-vanFleet.pdf>. (Accessed April 2020).
- Hammer Ø, Harper D A T & Yayan P D, Paleontological statistics software for education and data analysis: Paleontological electronica (Version 4, 2020) 4(1)(2001) 9. <http://folk.uio.no/ohammer/past/>. (Accessed May 2020).
- Casagrande D G, Ecology, cognition, and cultural transmission of *Tzeltal Maya* medicinal plant knowledge, A Ph. D thesis (unpublished), (The University of Georgia, USA), 2002, <https://www.lehigh.edu/~dac511/pdfs/casagrande.diss.pdf>.
- Jeyaprakash K, Lego Y J, Payum T, *et al.*, Diversity of medicinal plants used by *Adi* community in and around area of *D' Ering* wildlife sanctuary, Arunachal Pradesh, India, *World Scientific News*, (2017), <http://www.worldscientificnews.com/wp-content/uploads/2016/11/WSN-65-2017-135-159-1.pdf>. (Accessed April 2020)
- Adnan N & Othman N, The relationship between plants and the Malay culture, *Proc- Soc Behav Sci* 42 (2012) 231–241.
- Singh R K, Singh K P & Turner N J, A special note on Prior Informed Consent (PIC)-Why are you asking our *gyan* (knowledge) and *padhati* (practice)? Ethics and prior informed consent for research on traditional knowledge systems, *Indian J Tradit Know*, 3 (2013) 547-562.