Ethnobotanical Documentation of Harike Wildlife Sanctuary (Ramsar Site), Punjab: A Case Study

Sameer Gautam[*] and B.S. Adhikari

Department of Habitat Ecology, Wildlife Institute of India, Dehradun, Uttarakhand, India

Abstract

The present study deals with the systematic documentation of traditional knowledge on medicinal plants used by local people. The data was collected with the help of a semi-structured questionnaire following the snowball sampling method. People with some knowledge of medicinal plants were targeted for gathering information. A total of 85 species from 79 genera and 51 families were mentioned by informants for the treatment of 40 types of health ailments. For the use of plants as medicine, 110 informants from 6 villages were interviewed. Leaves (25% species) are the most used plant part and decoction (19 species) is the most used method for preparation of the drug, while the most frequent administration of the drug is oral (85% species) in the present study. The ethnobotanical indices like use value, relative importance and Fidelity Level (FL) of each species have been derived from the primary dataset. To confirm the plant availability and identification, various field surveys were conducted along with informants across the habitat types within Harike wildlife sanctuary. Besides the harvest time of different wild plants mentioned by informants and the development of conservation policies for the medicinal plant sector, the database is prepared.

Keywords: Conservation • Ethnobotany • Fidelity level • Medicinal plants • Use value

Introduction

Traditional health management practices with medicinal plants have been supporting human civilizations globally and being used to extract useful phytochemicals to produce modern medicine [1]. The medicinal plants are usually accessible in plenty, particularly in the tropics. The effectiveness of any healthcare system endures due to suitable medicines. The marginal communities of society are unable to afford the cost of modern medicines hence medicinal plants are essential for healthcare [2]. Around 80% of people in Asia and Africa use traditional medicine [3]. The Ayurveda, Unani and Siddha healthcare systems is evolved with medicinal plants in the course of a sequence of several centuries. In India, there are around 2500 species of plant used for traditional medicine, where 100 species are serving as a regular source of plant based remedies for healthcare [4]. About 80% of the population of developing counties is actively engaged in using medicinal plants to treat health ailments [5]. The continuous rapid destruction of natural habitats is leading to the shrinking of the sources led to the loss of biodiversity as well as the population of medicinal plants. Therefore, the studies of ethnobotanical are important for developing conservation strategies. The use of traditional knowledge of plant materials for disease treatment and prevention has gotten a lot of attention from the plant based research community, which has led to an increase in drug discovery based on phytochemicals [6,7]. There are many bioactive compounds usually acquired from plants. Few medicinal plants like *Tribulus terrestris* and *Urena lobata* has been identified as a repository of diosgenin and quercetin, respectively, *Acacia catechu* contains catechin and a climber *Basella alba* produces carotenoids [8]. Harike Wildlife Sanctuary (HWS) is a natural bank of medicinal plants and native flora, therefore regular monitoring is required to maintain such diversity as there are many natural and anthropogenic pressures like an invasion of alien species and encroachment. The objective of the present study is to document the medicinal plants used by local people settled around HWS besides to develop a systematic record of traditionally used medicinal plants.

Study area

The study is one of the largest man-made wetland of north India, established in 1952 at the confluence of Beas and Sutlej rivers and designated as a Ramsar site in the year 1990, *i.e.* Harike Wildlife Sanctuary (HWS). It is located between 31 °05'15" to 31 °14'15" N Lat. and 74° 55'30" to 75° 07'30" E Long in the state of Punjab. The sanctuary is spreading over an area of approximately 86 sq. km (Figure 1), sharing its boundaries with Ferozpur, Tarn Taran and Kapurthala districts of the state Punjab. Harike wetland is also a foundation of the extensive Indira Gandhi Canal with two channels,

Rajsthan (650 km) and Ferozpur (51.3 km), which provide water supply to Punjab, Haryana and Rajasthan states.
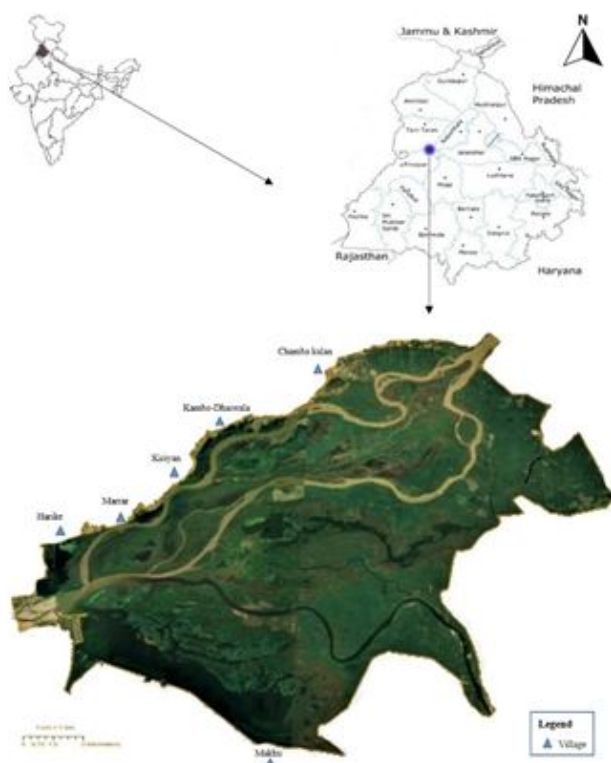

Figure 1. Location of villages along harike wildlife sanctuary.

The diversity of habitats in the Sanctuary supports a number of medicinal plants with high population including *Withania somnifera, Terminalia bellirica, Boerhavia diffusa, Bacopa monnieri and Centella asiatica*. The sanctuary is interspersed with agricultural fields and villages.

Materials and Methods

Ethno-botanical data was collected through semi-structured interviews and observations were recorded during the field surveys held between September 2019 and March 2021. A total of 110 informants were interviewed and the composition of informants includes medicinal plant collectors, traditional drug makers, farmers, daily wage labourers, and government servants. A semi-structured questionnaire was used for data collection following the snowball sampling [9]. The field observations with some informants have been made for the confirmation of plant species mentioned for the treatment of ailments, besides field surveys have been carried out across the habitat types in HWS to record the status and distribution of medicinal plants mentioned by informants. Direct and indirect evidence has also been recorded for the collection of medicinal plants from the sanctuary. The wild plants mentioned by the informant have been identified by following Nair 1978 and Sharma 1990 with some online resources were used. Plants species were photographed from the field and a voucher specimen of pictures has been submitted to the herbarium of the Wildlife Institute of India (WII) [10].

Data analysis

Use value: To find out the significant plant species used by people, the Use Value (UV) index is calculated according to Rossato et al. and Silva and Albuquerque.

$UVU : \Sigma U_i/N_i$

U_i=Number of uses mentioned by all informants.

N_i=Number of the informant.

For example: If informant A has mentioned 2 uses and informant B has mentioned 6 uses, therefore, the use value will be (2+6)/2=4.

Relative importance index: The relative importance index is calculated by following Bennett and Prance.

RI=NUC+NT

NUC=Number of use categories of a given species divided by the total number of most versatile species in use categories.

NT=Is given by the number of kinds of uses attributed to a given species divided by the total number of types of uses attributed to the most important taxon.

Fidelity level: This is adopted from Friedman et al. to determine the particular medicinal plant used for certain ailments. A high percentage shows that the given species is used by people for treatment of a particular ailment.

Fidelity Level (FL)=I p/I u × 100

Ip=Number of informants that cited the principal use of the species.

Iu=The total number of informants that cited the species for any purpose.

The distribution of medicinal plants has been recorded from wild sources after direct field visits conducted on monthly basis from September 2019 to March 2021. A timeline chart for the availability of medicinal plants in the HWS is also been mentioned in the study.

Results and Discussion

Demographical details

The sanctuary is surrounded by agricultural fields and villages; the major population is engaged in mixed farming. Harike and Marrar village is the largest and smallest village around the sanctuary respectively [11]. Developing fine communication between informants is necessary therefore gathering information is always starts with informal talks. After developing a familiarity with the informant, various questions had been asked. A total of 110 informants from six villages (22 from Makhu, 28 from Harike, 8 from Marrar, 15 from Kiriyan, 10 from Kambo-Dhaiwala and 27 from Chamba Kalan) belonged to different age groups and gender (87 men and 23 women) were interviewed for ethnobotanical use of plants, including literacy level and occupation (Table 1).

Variable	Category	Number of individuals
Gender	Male	87
	Female	23
Age	<30 years	6
	30-40 years	20
	40-50 years	22
	>50 years	62
Educational level	Illiterate	47
	< matriculation	45
	>matriculation	18

Table 1. Demographical information.

The literacy level of informants was in the order: Illiterate (42.7%) >below matric (40.9%) >above matric (16.4%). The informants from the age group above 50 years were found to be more aware of the use and identification of medicinal plants [12]. During the investigation, 3 individuals were found engaged in practicing drug preparation and sale, while 5 individuals were involved in the collection of medicinal plants. The knowledge of medicinal plants has been observed at a young age (<40 years), but they were unable to identify the wild medicinal plants, besides many elder informants also accepted that there is a depletion in the population of medicinal plants and loss of biodiversity due to habitat destruction and conversion of habitats into agricultural fields [13].

Taxonomic details

A total of 85 species belonging to 79 genera and 51 families have been mentioned by the informants to treat 40 ailments (Table 2).

Habit	Species	Genus	Family
Climber	6	5	4
Grasses	2	2	1
Herbs	44	41	26
Shrubs	10	10	3
Trees	23	21	17

Table 2. Number of species, genera and family according to habit.

The maximum number of species was recorded from Leguminosae family (4 species), followed by Apiaceae, Apocynaceae, Brassicaceae, Euphorbiaceae, Lamiaceae, Myrtaceae, Papaveraceae, Rutaceae, Solanaceae, Zingiberaceae (3 species each) and Amaranthaceae, Amaryllidaceae, Combretaceae, Cucurbitaceae, Lythraceae, Malvaceae, Meliaceae, Moraceae, Phyllanthaceae, Poaceae (2 species each), while 30 families were represented by single species [14]. Herbs (51.8%) were recorded as the most used habit of medicinal plants mentioned by informants followed by trees (27.1%), shrubs (11.8%), Climbers (7.1%) and grasses (2.4%). There are 49 species common to the study conducted by Sidhu et al. (2011) with major species like *Allium cepa, Acacia nilotica, Allium sativum, Aegle marmelos, Aegle marmelos, Brassica campestris, Bryophyllum pinnatum, Argemone mexicana, Azadirachta indica, Citrus reticulate* and *Euphorbia hirta*. The study conducted in Kapurthala district of Punjab by Kaur et al. shows that 29 species are common with major species like *Abutilon indicum, Achyranthes aspera, Aegle marmelos, Asparagus racemous, Cinnamomum zeylanicum, Cassia fistula,* and *Ficus benghalensis*. However, Sidhu et al. reported 50 species common from Jalandhar district of Punjab and the major species includes *Achyranthes aspera, Argemone mexicana, Bacopa monnieri, Bryophyllum pinnatum, Calotropis procera, Brassica campestris, Camellia thea, Carica papaya, Cannabis sativa, Cassia fistula, Curcuma longa, Emblica officinalis, Ficus palmate, Fumaria indica* and *Piper nigrum* [15].

Species used under various ailments

The ailments mentioned by the informants have been classified under 15 major ailments' categories along with the medicinal plant species (Figure 2) used are in following order: Gastro-intestinal with 48 species (ailments: constipation (15 species), diarrhea (12 species), indigestion (7 species), piles and stomachache (5 species each), gastritis (3 species), ulcer (1 species)) >circulatory with 19 species (ailments: diabetes (13 species), anaemia (3 species), blood pressure (2 species), blood infection (1 species)) and general with 17 species (ailments: fever (8 species), cough and cold (5 species), headache (3 species), bee sting (1 species) >dental with 11 species (ailments: bad breath (1 species), periodontitis (5 species) and toothache (5 species)), skeleton and muscle with 10 species (ailments: arthritis (2 species), body pain (5 species), weakness (3 species)), respiratory with 9 species (ailments: asthma (5 species), lung infection (4 species)) and dermatological with 9 species

(ailments: skin (ailments: skin disease (5 species), cut and wound (4 species)) >vital organs with 7 species (ailments: cardiovascular disease (1 species), kidney stone (2 species), liver disorder (4 species)) and vector-borne with 7 species (ailments: malaria (3 species), dengue (4 species)) and body heat (ailment: heatstroke) with 7 species >mental with 6 species (ailments: memory loss (1 species), mental disorder (3 species), insomnia (2 species)), genital with 6 species (ailments: sexual disorder (4 species), urinary tract infections (1 species), azoospermia (1 species)) and>hepatic with 2 hair with 6 species (ailment: hair loss)species (ailment: jaundice) >ophthalmic with 1 species (ailment: eye irritation). The detailed description of each medicinal plant is mentioned in annexure II.
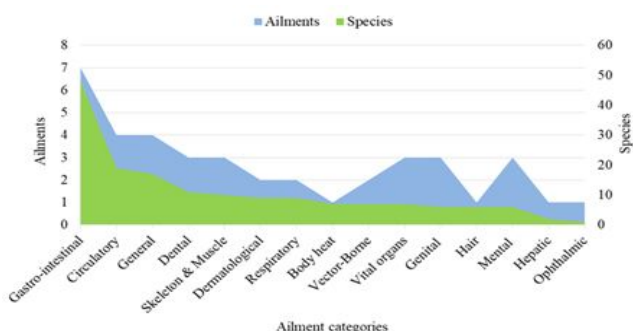

Figure 2. Number of species recorded under various ailment categories.

Plant parts used

The plant parts used (Figure 3) for medicinal purposes to treat various ailments are in the following order:
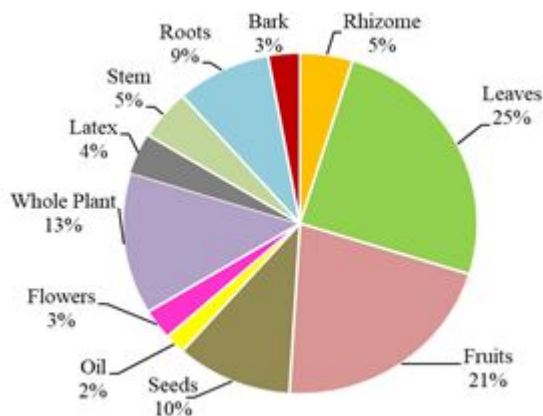

Figure 3. Plant parts used.

Leaves (26 species)>fruits (22 species)>whole plant (14 species) > seeds (11 species)> roots (9 species)>stem ≈ rhizome (5 species each)>latex (4 species)>flower ≈ bark (3 species)>oil (2 species).

The species like *Achyranthes aspera, Azadirachta indica, Withania somnifera, Moringa oleifera* and *Carica papaya* contribute for leaves; *Aegle marmelos, Cordia myxa, Kigelia Africana, Mangifera indica, Moringa oleifera, Musa paradisiaca, Phyllanthus emblica, Terminalia bellirica, Ziziphus nummularia,* and *Vachellia nilotica* for fruits; *Bacopa monnieri, Centella asiatica, Coriandrum sativum, Sisymbrium irio, Phyllanthus niruri, Euphorbia hirta, Cuscuta reflexa,* and *Fumaria indica* as whole plant;

Abrus precatorius, Achyranthes aspera, Asparagus officinalis, Azadirachta indica, Boerhavia diffusa, Beta vulgaris, Ficus palmate, and *Solanum virginianum* for roots; *Brassica campestris, Cleome viscosa. Piper nigrum, Sisymbrium irio. Trachyspermum ammi, Vachellia nilotica, and Trigonella foenum-graecum* for seeds; *Curcuma longa, Zingiber officinale, Allium sativum,* and *Allium cepa* for rhizome; *Azadirachta indica, Mimusops elengi, Achyranthes aspera, Nerium oleander* and *Pongamia pinnata* for stems; *Ficus palmata, Ficus benghalensis, Calotropis procera,* and *Argemone Mexicana* for latex; *Azadirachta indica, Cinnamomum verum,* and *Terminalia arjuna* for bark; *Catharanthus roseus, Hibiscus rosa-sinensis,* and *Syzygium aromaticum* for flowers and *Brassica campestris,* and *Ricinus communis* for oil.

Source for collection of medicinal plants

The medicinal plants were collected by the local inhabitants from various sources, such as from wilderness areas, agricultural lands, wilderness areas/agricultural lands and from market (Figure 4) The study area is primarily dominated by the agricultural fields, which supports many cultivated species, among them 23 species used for medicinal purposes as cited by the informants. *Curcuma longa, Allium sativum, Zingiber officinale, Bryophyllum pinnatum, Ocimum tenuiflorum, Brassica campestris, Ocimum basilicum, Raphanus sativus, Trigonella foenum-graecum, Beta vulgaris, Murraya koenigii,* and *Allium cepa* were the common species. However, species like *Asparagus officinalis, Mangifera indica, Phyllanthus emblica, Syzygium cumini, Psidium guajava, Moringa oleifera, Melia azedarach, Papaver rhoeas, Mangifera indica* and *Nerium oleander* were collected from the wilderness areas. The maximum species (45 species) were collected from the wilderness areas according to informants and the prominent species were *Tinospora cordifolia, Datura metel, Cannabis sativa, Tribulus terrestris, Phyla nodiflora, Pedalium murex, Cordia myxa, Withania somnifera, Achyranthes aspera, Ricinus communis, Bacopa monnieri, Nyctanthes arbor-tristis, Calotropis procera* and *Lawsonia inermis.* The species like *Piper longum, Piper nigrum, Trachyspermum ammi, Syzygium aromaticum, Camellia sinensis, Amomum subulatum,* and *Cinnamomum verum* were procured from the market only (Figure 4).

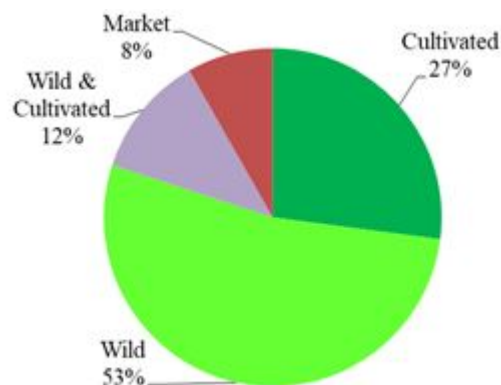**Figure 4.** Sources of medicinal plants.

Preparation of drug

Various modes of consumption of medicinal plants for the treatment of different ailments mentioned by informants are shown in Figure 5. The treatment of different ailments with the change in combination is in the following order:
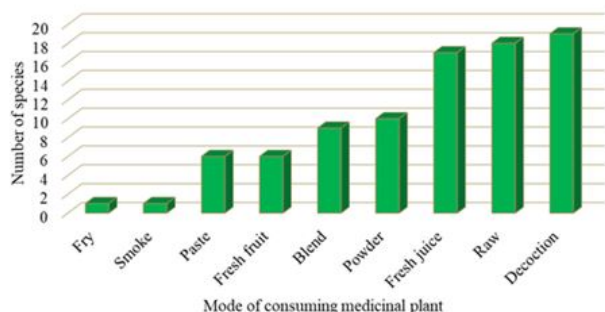

Figure 5. Mode of consuming medicinal plants.

Decoction (19 species)>raw form (18 species)>fresh juice (17 species)>powder (10 species)>blend (9 species)>fresh fruits (6 species)>paste (6 species)>smoke ≈ fry (1 species each)

The important species used for decoction: *Tinospora cordifolia, Justicia adhatoda, Fumaria indica, Cleome viscosa, Cinnamomum verum, Chenopodium ambrosioides, Amomum subulatum, Piper nigrum, Curcuma longa and Zingiber officinale*; as raw forms: *Abutilon indicum, Allium sativum, Azadirachta indica, Euphorbia hirta, Euphorbia prostrate, Withania somnifera and Zingiber officinale*; as fresh juice: *Aegle marmelos, Punica granatum, Phyllanthus niruri, Citrus aurantium, Lagenaria siceraria, Raphanus sativus, Allium cepa and Carica papaya;* as powder: *Abrus precatorius, Curcuma longa, Terminalia bellirica, Tribulus terrestris, Vachellia nilotica, Withania somnifera and Tribulus terrestris;* as blend or juice: *Aegle marmelos, Carica papaya, Brassica campestris, Beta vulgaris, Zingiber officinale, Ricinus communis, Hibiscus rosa-sinensis, Mangifera indica and Ficus palmata;* as fresh fruits: *Cordia myxa, Phyllanthus emblica, Ziziphus nummularia and Syzygium cumini;* as paste: *Lawsonia inermis, Mimusops elengi, Oxalis corniculata, Papaver rhoeas and Phyla nodiflora,* while *Cannabis sativa* as smoke and *Sisymbrium irio* as fry administered to cure the various ailments [16].

Administration of drug

The drugs administered orally were 84.7% and the major species were *Withania somnifera, Phyllanthus emblica, Piper longum, Terminalia arjuna, Tinospora cordifolia, Vachellia nilotica, Phyllanthus emblica, Raphanus sativus* and *Justicia adhatoda*. The drugs administered topical were 11.8% and the major species were *Ageratum conyzoides, Argemone mexicana, Calotropis procera, Cuscuta reflexa, Eclipta prostrata, Ficus palmata, Hibiscus rosa-sinensis, Lawsonia inermis, Mimusops elengi* and *Nerium oleander*. However, the drugs administered orally/Topical were 3.5% and the species were *Allium cepa, Azadirachta indica* and *Mangifera indica* [17].

Use value

The UV of medicinal plants ranged from 1.8 to 0.3 in the study area. The higher UV indicates more utilization of a species. Species with high UV are *Tinospora cordifolia* and *Curcuma longa* (1.8 each), *Piper longum* and *Allium sativum* (1.2 each), *Zingiber officinale* (1.0), *Euphorbia hirta, Azadirachta indica* and *Justicia adhatoda* (0.9 each) and Withania somnifera (0.8). However, species with low UV are *Fumaria indica* (0.09), *Pedalium murex* (0.09), *Tribulus terrestris* (0.08), *Cannabis sativa* (0.06), *Phyllanthus niruri* (0.06) and *Datura metel* (0.03). The UV of documented species is given in annexure II.

Relative Importance (RI)

The RI (Annexure II) has been driven by the number of ailment categories for a particular species and the number of uses for concerned species, therefore the species which were recorded under various uses with multiple ailment categories exhibit higher value. The higher RI of medicinal plants suggests the level of awareness and use for the treatment of various ailments. In the present study, the higher RI were recorded for *Allium sativum* with RI value 2 (7 uses under 5 ailment categories) followed by *Azadirachta indica* with RI value 1.86 (6 uses under 5 ailment categories), *Curcuma longa* with RI value 1.51 (5 uses under 4 ailment categories) and *Withania somnifera, Punica granatum, Oxalis corniculata* and *Cleome viscosa* with RI value 1.37 (each with 4 uses under 4 ailment categories). The least RI value (0.34) was recorded for *Ricinus communis, Ficus benghalensis, Amomum subulatum, Hibiscus rosa-sinensis, Lawsonia inermis, Argemone Mexicana, Catharanthus roseus, Ficus palmata* and *Sisymbrium irio*.

Fidelity Level (FL)

FL is useful to know the most preferred species used by the informants for treating certain ailments and is given in Table 3.

Species	Fidelity level
Anemia	
Beta vulgaris L.	76.2
Phoenix sylvestris (L.) Roxb.	90
Punica granatum L.	92.3
Arthritis	
Vachellia nilotica (L.) P.J.H. Hurter and Mabb	

Calotropis procera (Aiton) Dryand.	
Asthma	
Allium cepa L.	87.5
Justicia adhatoda L.	88.2
Withania somnifera (L.) Dunal	80
Syzygium cumini var. cumini	28.6
Sisymbrium irio L	100
Azoospermia	
Ficus benghalensis L.	100
Bad breath	
Ocimum basilicum L	46.3
Bee sting	
Oxalis corniculata L	32
Blood infection	
Fumaria indica (Hausskn.) Pugsley	80
Blood pressure	
Zingiber officinale Roscoe	45.7
Allium sativum L.	27.6
Body pain	
Ziziphus nummularia (Burm.f.) Wight and Arn.	71.4
Brassica rapa var. rapa L.	83.9
Calotropis procera (Aiton) Dryand.	58.8
Phoenix sylvestris (L.) Roxb.	80
Curcuma longa L.	73.9
Cardiovascular disease	
Terminalia arjuna (Roxb. ex DC.) Wight and Arn.	100
Cold and cough	
Solanum virginianum L.	57.1
Achyranthes aspera L.	61.5
Zingiber officinale Roscoe	83
Brassica rapa var. rapa L.	87.1
Trachyspermum ammi (L.) Sprague	87.5
Piper nigrum L.	88.9
Justicia adhatoda L.	90.9
Piper longum L.	92.7
Allium sativum L.	96.6
Syzygium aromaticum (L.) Merr. and L.M.Perry	97.6
Curcuma longa L.	97.8
Ocimum tenuiflorum L.	98.4

Species	Fidelity level
Cinnamomum verum J.Presl	100
Cleome viscosa L	76.9
Constipation	
Ziziphus nummularia (Burm.f.) Wight and Arn.	71.4
Fumaria indica (Hausskn.) Pugsley	40
Aloe vera (L.) Burm.f.	43.5
Psidium guajava L.	83.3
Beta vulgaris L.	85.7
Species	Fidelity level
Terminalia bellirica (Gaertn.) Roxb	76.5
Murraya koenigii (L.) Spreng	73.1
Mangifera indica L	71.4
Phyllanthus emblica L.	89.7
Carica papaya L	76.9
Kigelia africana	94.4
Cleome viscosa L	76.9
Cordia myxa L.	100
Raphanus sativus L.	77.8
Ricinus communis L.	100
Cut and wound	
Azadirachta indica A. Juss.	58
Eclipta prostrata (L.) L.	73.9
Brassica rapa var. rapa L.	64.5
Oxalis corniculata L	80
Bryophyllum pinnatum (Lam.) Oken	41.7
Ageratum conyzoides L.	100
Dengue	
Nyctanthes arbor-tristis L.	81.5
Tinospora cordifolia (Willd.) Miers	82.9
Carica papaya L	92.3
Punica granatum L.	88.5
Diabetes	
Azadirachta indica A. Juss.	53.6
Moringa oleifera Lam	87.5
Terminalia bellirica (Gaertn.) Roxb	88.2
Murraya koenigii (L.) Spreng	46.2
Justicia adhatoda L.	78.2
Syzygium cumini var. cumini	95.2
Allium sativum L.	34.5

Catharanthus roseus (L.) G.Don	100
Lagenaria siceraria (Molina) Standl.	100
Melia azedarach L.	100
Momordica charantia L.	100
Terminalia arjuna (Roxb. ex DC.) Wight and Arn.	66.7
Trigonella foenum-graecum L	100
Diarrhoea	
Ziziphus nummularia (Burm.f.) Wight and Arn.	35.7
Tribulus terrestris L.	55.6
Aloe vera (L.) Burm.f.	76.1
Aegle marmelos (L.) Correa	81
Psidium guajava L.	83.3
Trachyspermum ammi (L.) Sprague	35.7
Euphorbia prostrata Aiton	55.6
Oxalis corniculata L	76.1
Camellia sinensis (L.) Kuntze	81
Cynodon dactylon (L.) Pers.	83.3
Euphorbia hirta L.	35.7
Musa x paradisiaca	55.6
Eye irritation	76.1
Allium cepa L.	81
Fever	83.3
Azadirachta indica A. Juss.	35.7
Fumaria indica (Hausskn.) Pugsley	55.6
Aegle marmelos (L.) Correa	76.1
Nyctanthes arbor-tristis L.	81
Species	83.3
Tinospora cordifolia (Willd.) Miers	35.7
Curcuma longa L.	55.6
Cleome viscosa L	76.1
Terminalia arjuna (Roxb. ex DC.) Wight and Arn.	81
Gastritis	83.3
Zingiber officinale Roscoe	35.7
Allium sativum L.	55.6
Mentha piperita L.	76.1
Hair loss	
Beta vulgaris L.	35.7
Eclipta prostrata (L.) L.	55.6
Phyllanthus emblica L.	76.1

Cuscuta reflexa Roxb.	81
Hibiscus rosa-sinensis L.	83.3
Lawsonia inermis L.	35.7
Headache	55.6
Citrus aurantium L.	76.1
Punica granatum L.	81
Centella asiatica (L.) Urb.	83.3
Heatstroke	
Citrus aurantium L.	35.7
Chrysopogon zizanioides (L.) Roberty	55.6
Coriandrum sativum L.	76.1
Bacopa monnieri (L.) Wettst.	81
Mangifera indica L	83.3
Oxalis corniculata L	35.7
Centella asiatica (L.) Urb.	55.6
Indigestion	76.1
Aloe vera (L.) Burm.f.	81
Zingiber officinale Roscoe	38.3
Ocimum basilicum L	87
Moringa oleifera Lam	62.5
Terminalia bellirica (Gaertn.) Roxb	58.8
Murraya koenigii (L.) Spreng	88.5
Phyllanthus emblica L.	68
Allium sativum L.	43.7
Amomum subulatum Roxb.	100
Mentha piperita L.	85
Insomnia	
Cannabis sativa L.	38.3
Datura metel L.	87
Jaundice	62.5
Phyllanthus niruri L	58.8
Raphanus sativus L.	88.5
Kidney stone	
Boerhavia diffusa L.	55
Bryophyllum pinnatum (Lam.) Oken	95.2
Liver disorder	
Solanum virginianum L.	71.4
Achyranthes aspera L.	35.4
Moringa oleifera Lam	81.3

Murraya koenigii (L.) Spreng	84.6
Syzygium cumini var. cumini	81
Lung infection	
Tinospora cordifolia (Willd.) Miers	71.4
Piper longum L.	35.4
Ocimum tenuiflorum L.	81.3
Species	84.6
Cleome viscosa L	81
Malaria	71.4
Tinospora cordifolia (Willd.) Miers	35.4
Punica granatum L.	81.3
Withania somnifera (L.) Dunal	84.6
Memory loss	81
Bacopa monnieri (L.) Wettst.	71.4
Mental disorders	35.4
Cannabis sativa L.	81.3
Datura metel L.	84.6
Papaver rhoeas L	81
Periodontitis	
Achyranthes aspera L.	30.8
Azadirachta indica A. Juss.	37.7
Psidium guajava L.	55.6
Pongamia pinnata (L.) Pierre	73.9
Vachellia nilotica (L.) P.J.H. Hurter and Mabb	81.3
Nerium oleander L.	53.3
Syzygium aromaticum (L.) Merr. And L.M.Perry	78.1
Cordia myxa L.	66.7
Mimusops elengi L.	100
Piles	
Euphorbia prostrata Aiton	79.3
Kigelia africana	88.9
Chenopodium ambrosioides L.	100
Euphorbia hirta L.	100
Phyla nodiflora (L.) Greene	100
Sexual disorder	
Tribulus terrestris L.	77.8
Abutilon indicum (L.) Sweet	40
Asparagus officinalis L.	81
Boerhavia diffusa L.	90

Withania somnifera (L.) Dunal	94.1
Allium sativum L.	54
Abrus precatorius L.	100
Pedalium murex L.	100
Skin disease	
Aloe vera (L.) Burm.f.	80.4
Brassica rapa var. rapa L.	58.1
Curcuma longa L.	62
Argemone mexicana L.	100
Ficus palmata Forssk.	100
Stomachache	
Citrus aurantium L.	48.5
Chrysopogon zizanioides (L.) Roberty	72.7
Azadirachta indica A. Juss.	69.6
Ocimum basilicum L	68.5
Euphorbia prostrata Aiton	86.2
Withania somnifera (L.) Dunal	65.9
Kigelia africana	94.4
Centella asiatica (L.) Urb.	78.1
Chenopodium ambrosioides L.	62.5
Euphorbia hirta L.	63.5
Phyla nodiflora (L.) Greene	70
Toothache	
Achyranthes aspera L.	76.9
Species	Fidelity level
Pongamia pinnata (L.) Pierre	87
Vachellia nilotica (L.) P.J.H. Hurter and Mabb	62.5
Nerium oleander L.	76.9
Syzygium aromaticum (L.) Merr. and L.M.Perry	Fidelity level
Ulcer	87
Azadirachta indica A. Juss.	62.5
Urinary tract infections	76.9
Coriandrum sativum L.	Fidelity level
Weakness	87
Abutilon indicum (L.) Sweet	62.5
Asparagus officinalis L.	76.9
Boerhavia diffusa L.	Fidelity level

Table 3. Fidelity level of each species under various ailments.

The FL specifies that the certain species are used for the treatment of a particular ailment and is expressed in percent is given in Table 3. The FL values for different ailments like fever, blood infection and constipation was 70, 80 and 40%, respectively shown by *Fumaria indica*. Similarly, FL values of *Withania somnifera* was 91.8% for malaria, 94.1% for sexual disorder and 65.9%

for Stomachache. The species with 100% FL values for the treatment of certain ailments include *Catharanthus roseus* (Diabeties), *Camellia sinensis* (Diarrhoea) Cleome viscosa (Fever), *Mimusops elengi* (Periodontitis), *Argemone Mexicana* (Skin disease), *Amomum subulatum* (Indigestion), *Datura metel* (Insomnia) and *Phyllanthus niruri* (Jaundice) [18].

Collection of medicinal plants

HWS harbour 6 major habitat types, *viz*. Plantation, agricultural field, swampy, wetland, sandy and ravine areas, which support variety of plants including the medicinal plants are shown in Figure 6. The harvesting time of different medicinal plants have been recorded to estimate annual availability of wild medicinal plants for locals. A total of 45 medicinal plant species are collected from wild and the mean number of species available for harvesting in a year at any point of time is 25.4 ± 8.4 species.
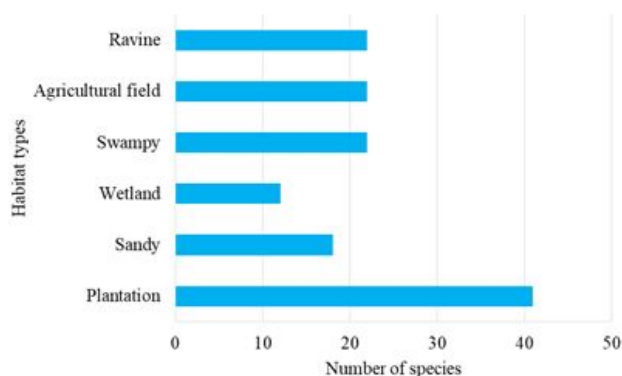

Figure 6. Distribution of wild medicinal plants across the habitat types.

Nine species found throughout the year for medicinal use are (tree: *Azadirachta indica, Ficus benghalensis, Ficus palmata, Mimusops elengi, Pongamia pinnata, Terminalia arjuna, Vachellia nilotica;* shrub: *Calotropis procera* and herb: *Withania somnifera*). It has been observed that there is a seasonal variability in the availability of medicinal plants for collection and shown in Figure 7.

Figure 7. Availability of wild species as per month.

There are 13 medicinal plant species available for harvest in the winter season (January-February) including species like *Abrus precatorius, Ageratum conyzoides, Sisymbrium irio* and *Ziziphus nummularia*. A total of 27 species including *Tribulus terrestris, Cleome viscosa, Argemone Mexicana, Justicia adhatoda,* and *Boerhavia diffusa* are available for harvest in summer season (March-June), wherein 37 species comprising *Euphorbia hirta, Bacopa monnieri, Centella*

asiatica, Cordia myxa, Datura metel, Nyctanthes arbor-tristis and *Tinospora cordifolia* can be found in monsoon season (July-September). However, 27 species including *Chrysopogon zizanioides, Kigelia Africana, Pedalium murex, Terminalia bellirica* and *Ricinus communis* are available for harvest in the post-monsoon season (October-December). Some medicinal plants are seasonal, and hence not available throughout the year for use. The timeline chart of medicinal plants available in the field is given in annexure I [19].

Conclusion

The present study has been carried out while determining the benefits of provisioning ecosystem services at HWS. The study revealed that there are many species used for the treatment of various health ailments, even though modern health services are also available in the study area. Senior citizens were found more aware of plant identification and its use for health benefits. In order to create an opportunity for the collection of germplasm for *ex-situ* conservation of medicinal plants in future, the documentation on the availability of wild medicinal plant species in different habitats has been done. The timeline chart may be useful in order to observe the phenology of a particular medicinal plant for the best suited time for collection. The loss of biodiversity is a known fact in the present era, therefore documentation of ethnobotanical use of plants from the different areas can produce precise information for the traditional use of plants, and besides this the present study might contribute to the conservation of medicinal and aromatic plants by developing an effective strategy.

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