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Population Assessment of Some Important Threatened Medicinal Plants in Himachal Pradesh, Northwestern Himalaya

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ABSTRACT: Biodiversity loss, also called loss of biodiversity, is due to various anthropogenic and natural factors. This loss is typically associated with permanent ecological changes in ecosystems, landscapes, and the global biosphere. Natural ecological disturbances, such as wildfire, floods, and volcanic eruptions, change ecosystems drastically by eliminating local populations of some species and transforming whole biological communities. Therefore, it is essential to identify suitable conservation priorities in biodiversity rich areas. The study has been conducted because of the dearth of the specific studies in the Indian Himalayas for assessing the 'threatened species'. Himachal Pradesh, in the Indian Himalaya, has a rich diversity of medicinal plants, which are widely used. This paper brings together existing information with the results from recent field surveys on population assessment of some important threatened medicinal plants in Himachal Pradesh, Northwestern Himalaya. Existing strategies for *in-situ* and *ex-situ* conservation, cultivation and propagation are reviewed and a range of actions for cooperative implementation by all stakeholders are suggested. Potential species have been suggested in view of economic importance. Regular monitoring of populations and habitats of threatened medicinal plants, restricted harvesting and habitat protection are suggested.

Keywords: Indian Himalaya Region; Red Data Book; Threatened Species; Medicinal Plants and Northwestern Himalaya.

INTRODUCTION: Fossil records date, human use of plants as medicines at least to the Middle Paleolithic age some 60,000 years ago. According to the World Health Organization (WHO), almost 65% of the world's populations have incorporated into their primary modality of health care. Out of the total 4, 22, 000 flowering plants reported from the world, >50,000 are used for medicinal purposes. Floral and faunal diversity, aesthetic, geo-hydrological and cultural values of the Indian Himalaya Region (IHR) are well known in the world. The Himalayan Region has been identified as one of the richest habitats for medicinal plants. The rich plant diversity of the IHR has been utilized by the inhabitants in various forms such as medicine, food (edible), fuel, fodder, agricultural tools, house building, in religious ceremonies, livestock grazing and various other purposes.[13]

In India, more than 43% of the total flowering plants are reported to be of medicinal importance. In the Indian Himalayan Region (IHR), 1748 species of medicinal plants have been recorded. Of these, 25.80% are native to the Himalayan region; 5.66% species native to the Himalayan region including the neighboring biogeographic domains; 62 species endemic to the IHR and 208 species near endemic.[13]

Out of the total 3500 flowering plants reported from the Himachal Pradesh, more than 643 species are used for medicinal purpose.[17] With the increasing world demand and renewed global interest in traditional ethnopharmacy coupled with the increasing preference for natural substances in the health care system, the natural stock of medicinal plants of Indian Himalayan Region (IHR) is under tremendous pressure. 121 species of vascular plants have been recorded in the Red Data Book of Indian Plants[10] and about 120 species of medicinal plants have been assessed for the various categories of rarity.[15, 19 & 20] In view of the richness of medicinal plants in the State, the State is being seen as a herbal state and medicinal plants as one of the major sources of income generation for the inhabitants in addition to other income generation activities from natural resources.[21-44]

MATERIALS AND METHODS:

Study area: The State Himachal Pradesh (30^0 22' 40" to 33^0 12'40" North latitude and 75^0 47'55" to $79^0$04'20" East longitude) covers the parts of Trans and North-Western Himalaya. It is bounded by Tibet in the East, Jammu and Kashmir in the North, Uttaranchal in the South-East, Haryana in the South and the Punjab in the West. Physiographically, it is divided in three conspicuous zones, namely outer Himalaya or the Shiwaliks, inner Himalaya or mid mountain and the greater Himalaya or alpine zones. Five rivers namely Sutluj, Beas, Ravi, Yamuna, and Chenab with a large number of their tributaries flow through the State. It is known for its salubrious climate. It also experiences considerable variations in the distribution of rainfall and temperature due to varying aspects and altitude, precipitation declines from West to East and South to North.

The Kullu and Lahaul and Spiti districts of the State are rich in medicinal plant diversity. There is plenty scope for the promotion of medicinal plant cultivation and conservation and as such an integrated study on the conservation and sustainable utilization of the medicinal plants has not been carried out so far. Therefore, the study conducted in Upper Banjar valley (1500-3600), Mohal Khad Watershed (1,200-3,000m); Parbati Watershed (1,100- 6,500m), and Upper Beas Valley (2,300- 5,000m) in Kullu district and Chandra Valley (3,300-5,000) in Lahaul & Spiti district (Figure 1). Study areas support a large number of sensitive biodiversity elements counting medicinal, wild edible, rare endangered, native and endemic plants.

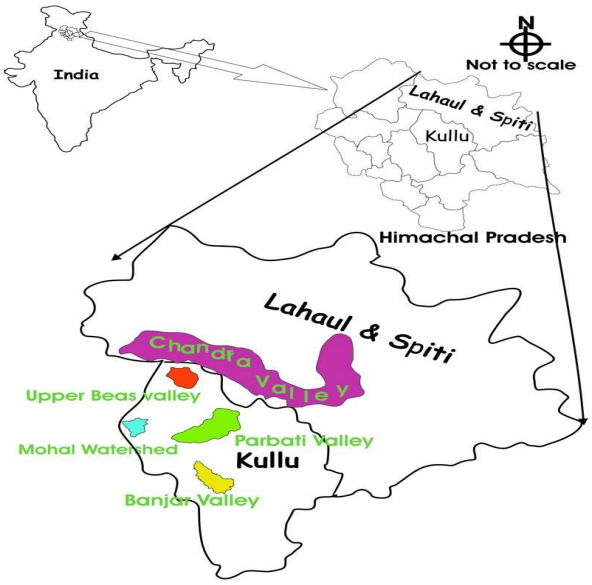

Figure 1: Study Area.

Method: The field surveys were conducted in the Upper Banjar valley, Mohal Khad Watershed, Parbati Watershed and Upper Beas Valley in Kullu district and Chandra Valley in Lahaul & Spiti district to assess the population of medicinal plant diversity and collect the medicinal plants. Participatory Rural Appraisal (PRA) followed for information generation on medicinal plants. Also, local knowledgeable persons including Vaidhyas interviewed. Information generated on the indigenous uses and commercial values. Among the knowledgeable persons, one person was hired to collect medicinal plants from the natural habitat(s). The specimens of each species were collected and identified with the help of floras, and research papers.[3, 4, 5, 9, 10, 11, 12 &18] Information on locality, altitudinal range, life form, habitat and other morphological characters was collected for each species. The data were compiled and analyzed for diversity and distribution pattern of the species following.[13 & 14] For the quantitative assessment of medicinal plant diversity, in the forest zone in each selected site, a plot of 50x50m laid. Trees, seedlings and saplings were sampled by randomly placed 10, 10x10m quardrats, shrubs by 20, 5x5m quardrats, and herbs by 20, 1x1m quardrats in each plot. For the quantitative assessment of the alpine herbs in each site, a plot of 20x20m laid, and herbs sampled by randomly placed 20, 10x 10m quardrats in each plot. For the collection of data from the quardrats and analysis for the various ecological parameters standard ecological methods have been followed.[7 & 16] From each site, samples of each species were collected and identified with the help of local and regional floras. Five soil samples were randomly collected from each site, preferably one from center and four from four corners. Soil cored upto 20cm depth. These samples mixed together and a composite sample weighing 200g brought in the laboratory and analyzed for the physico-chemical properties following.[1] The valuation of medicinal plant diversity was done based on the nativity, endemism and rare endangered plants (Conservation value) and utilization pattern (Socio-economic value). The nativity of the species was identified following[2 & 13] and endemism based on distribution range of the species and following[6 & 13] Status and distribution pattern was identified based on the field observations and analyzed data. The information on utilization pattern of medicinal plants was generated through Participatory Rural Appraisal (PRA) and interviews of the local knowledgeable persons including Vaidhyas (Samant et al. 2007). The threat categories of the medicinal plants were identified based on habitat preference, population size, distribution range, and use values.[13 & 19]

RESULTS AND DISCUSSION:

Population Assessment of the Threatened Medicinal Plants: Populations of seventeen (17) threatened medicinal plants were assessed. Site representation,

altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. Site wise pH, moisture content (%), total organic matter (%), total organic carbon (%), total nitrogen (%), and Carbon/Nitrogen ratio in the study areas were presented in Table 2. Site wise physical characteristics, dominant species and occurrence of threatened medicinal plants within the study areas were presented in Table 3. Species wise details are as follows:

1. *Angelica glauca*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley, this species was represented in 07 sites and in the Parvati Watershed in the 03 sites. The relative density of the species, In the Upper Banjar Valley, ranged from 0.27-3.04% and in the Parvati Watershed from 0.42-0.94%. The dominant species were *Acer acuminatum, Abies-pindrow, Prunus cornuta, Quercus semecarpifolia, Picea smithiana, Cedrus deodara* and *Pinus wallichianana.*

Soil composition: pH of sites supporting *Angelica glauca*in the Upper Banjar Valley ranged from 5.01-5.79; Moisture Content, 33.19-48.25 (%); Carbon, 2.40-7.46 (%) and Nitrogen, 0.07-0.84 (%) and in the Parvati Valley pH ranged from 6.12-6.98; Moisture Content, 7.05-18.84 (%); Carbon, 3.45-5.05 (%) and Nitrogen, 1.20-2.33 (%).

2. *Barberis aristata*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley and Parvati Watershed, this species was represented in 03 sites, each, and in the Mohal Khad Watershed in 08 sites. The relative density of the species, In the Upper Banjar Valley, ranged from 3.19-22.68%; in the Mohal Khad Watershed from 1.21-12.76% and in the Parvati Watershed from 1.71-8.88%. The dominant species were *Acer acuminatum, Abies pindrow, Prunus cornuta, Quercus semecarpifolia, Picea smithiana, Pinus-wallichianana, Salix denticulata.*

Soil composition: pH of sites supporting *Barberis aristata*in the Upper Banjar Valley ranged from 5.00-5.49; Moisture Content, 40.06-46.93%; Carbon, 6.38-7.46% and Nitrogen, 0.35-084%; in the Mohal Khad Watershed pH from 5.05-7.63; Moisture Content, 26.44-53.54%; Carbon, 2.60-6.37% and Nitrogen, 1.56-2.45% and in the Parvati Valley pH from 5.43-6.98; Moisture Content, 7.50-14.32%; Carbon, 1,54-4.73 % and Nitrogen, 1.2-2.00%.

3. *Barberis lycium*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley, this species was represented in 07 sites and in the Mohal Khad Watershed in 02 sites. The relative density of the species, In the Upper Banjar Valley, ranged from 5.33-41.67%; and in the Mohal Khad Watershed from 4.27-8.64%. The dominant species were *Acer acuminatum, Abies pindrow, Prunus cornuta, Quercus semecarpifolia, Picea smithiana, Pinus wallichianana, Salix denticulata.*

Soil composition: pH of sites supporting *Barberis lyceum* in the Upper Banjar Valley ranged from 5.53-7.20; Moisture Content, 10.82-33.19%; Carbon, 1.44-7.07% and Nitrogen, 0.42-1.68%; and in the Mohal Khad Watershed pH from 5.05-7.63; Moisture Content, 11.02-19.87%; Carbon, 1.59-1.63% and Nitrogen, 1.87-2.00% .

4. *Bergenia ciliata*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley, this species was represented in 03 sites. The relative density of the species ranged from 1.32-18.67%. The dominant species were *Aesculus indica, Picea smithiana, Abies pindrow, Taxus baccata, Viburnum cotonifolium* and *Rosa webbiana.*

Soil composition: pH of sites supporting ***Bergenia ciliata*** in the Upper Banjar Valley ranged from 4.76-6.24; Moisture Content, 14.72-3045%; Carbon, 1.28-6.08% and Nitrogen, 0.21-1.28%.

5. *Diascorea deltoidea*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley, this species was represented in 04 sites. The relative density of the species, ranged from 0.39-1.25%. The major species were *Aesculus indica, Picea smithiana, Ilex dipyrena, Acer acuminatum, Prunus cornuta* and *Juglans regia.*

Soil composition: pH of sites supporting *Diascoria deltoidea* ranged from 5.53-7.20; Moisture Content, 18.21-29.30%; Carbon, 1.44-5.55% and Nitrogen, 0.56-1.40%.

6. *Hedychium spicatum*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. Mohal Khad Watershed and Parvati Watershed, this species was represented in 01 site. The relative density of the species, In the Mohal Khad Watershed, is 1.67% and in the Mohal Khad Watershed 5.27%. The dominant species were *Acer acuminatum, Prunus cornuta, Juglans regia, Ilex dipyrena, Viburnum cotonifolium, Rosa webbianum, Aesculus indica* and *Picea smithiana.*

Soil composition: pH of site supporting *Hedychium spicatum* in the Mohal Khad Watershed is 7.63; Moisture Content, 26.44%; Carbon, 3.96% and Nitrogen, 1.68%; in the Parvati Watershed pH, 6.12; Moisture Content, 18.84%; Carbon, 3.45% and Nitrogen, 2.10%.

7. *Hiphophea salicifolia*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Parvati Watershed, this species was represented in 04 sites. The relative density of the species ranged from 23.08-81.82%. The dominant species were *Pinus wallichiana, Salix alba, Cedrus deodara, Viburnum cotonifolium* and *Rosa moschata.*

Soil composition: pH of sites supporting *Hiphophea salicifolia* in the Parvati Watershed ranged from 5.43-6.76; Moisture Content, 7.11-25-98%; Carbon, 1.63-6.21% and Nitrogen, 1.68-2.43%.

8. *Paris polyphyla*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley and Mohal Khad Watershed this species was represented in 07 sites, each. The relative density of the species, In the Upper Banjar Valley, ranged from 0.49-5.34%; and in the Mohal Khad Watershed from 0.07-1.04% The dominant species were *Aesculus indica, Cedrus deodara, Persea duthiei, Quercus leucotrichophora, Juglens regia, Cedrus deodara* and *Pinus wallichiana.*

Soil composition: pH of sites supporting *Paris polyphyla* in the Upper Banjar Valley ranged from 5.53-7.20; Moisture Content, 10.82-28.43%; Carbon, 1.44-7.07% and Nitrogen, 0.56-1.78%; and in the Mohal Khad Watershed pH from 5.05-7.63; Moisture Content, 26.44-53.54%; Carbon, 2.91-6.60% and Nitrogen, 1.56-2.45%.

9. *Podophyllum hexandrum*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley and Parvati Watershed this species was represented in 07 and 03 sites respectively. The relative density of the species, In the Upper Banjar Valley, ranged from 0.14-2.53%; and in the Parvati Watershed from 0.14-1.89%. The dominant species were *Aesculus indica, Juglens regia, Pinus wallichiana, Picea smithiana* and *Cedrus deodara.*

Soil composition: pH of sites supporting *Podophyllum hexandrum* in the Upper Banjar Valley ranged from 4.85-5.86; Moisture Content, 28.37-46.93%; Carbon, 6.50-7.75% and Nitrogen, 0.35-1.05%; and in the Parvati Watershed pH from 5.89-7.33; Moisture Content, 14-32-25.98%; Carbon, 1.63-6.21% and Nitrogen, 1.68-2.43% .

10. *Polygonatum multiflorum*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley, this species was represented in 01 site. The relative density of the species was 1.39%. The dominant species were *Aesculus indica, Quercus leucotrichophora, Pinus wallichiana* and *Picea smithiana.*

Soil composition: pH of site supporting *Polygonatum multiflorum* was 6.18; Moisture Content, 19.77%; Carbon, 3.38% and Nitrogen, 1.78%.

11. *Polygonatum verticillatum*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley, this species was represented in 07 sites, in the Mohal Khad Watershed and Parvati Watershed 01 site, each. The relative density of the species, In the Upper Banjar Valley, ranged from 0.52-6.08%; in the Mohal Khad Watershed 1.67% and in the Parvati Watershed 1.40%The dominant species were *Abies pindrow, Aesculus indica, Pinus wallichiana, Picea smithiana, Viburnum cotonifolium* and *Cedrus deodara.*

Soil composition: pH of sites supporting *Polygonetum verticillatum* in the Upper Banjar Valley ranged from 4.76-7.13; Moisture Content, 14.72-48.25%; Carbon, 1.28-7.57% and Nitrogen, 0.14-1.05%; in the Mohal Khad Watershed pH, 6.09; Moisture Content, 44.65%; Carbon, 3.96% and Nitrogen, 1.56% and in the Parvati Watershed pH, 6.13; Moisture Content, 7.11%; Carbon, 1.13% and Nitrogen, 1.87%.

12. *Rhododendron arboreum*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley this species was represented in 03 sites, each. The relative density of the species, In the Upper Banjar Valley, ranged from 3.84-5.56%. The dominant species were *Pinus wallichiana, Picea smithiana, Quercus leucotrichophora, Persea duthiei* and *Cedrus deodara.*

Soil composition: pH of sites supporting *Rhododendron arboretum* in the Upper Banjar Valley ranged from 5.53-6.57; Moisture Content, 10.82-29.30%; Carbon, 1.44-5.59% and Nitrogen, 0.56-1.68%.

13. *Rhododendron campanulatum*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley this species was represented in 07 sites, each. The relative density of the species, In the Upper Banjar Valley, ranged from 2.59-32.93%. The dominant species were

Abies pindrow, Quercus semecarpifolia, Prunus cornuta, Quercus semecarpifolia and *Acer acuminatum.*

Soil composition: pH of sites supporting *Rhododendron campanulatum* in the Upper Banjar Valley ranged from 5.00-6.24; Moisture Content, 14.72-48.25%; Carbon, 1.28-7.23% and Nitrogen, 0.14-1.05%.

14. *Rhododendron lepidotum*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley, this species was represented in 01 site. The relative density of the species was 7.38%. The dominant species were *Quercus leucotrichophora, Rhododendron campanulatum* and *Salix denticulata.*

Soil composition: pH of site supporting *Rhododendron lepidotum* 6.24; Moisture Content, 14.72%; Carbon, 1.28% and Nitrogen, 0.21%.

15. *Taxus baccata* sub. sp. *wallichiana*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley this species was represented in 12 sites, in the Mohal Khad Watershed and Parvati Watershed 01 site, each. The relative density of the species, In the Upper Banjar Valley, ranged from 1.52-57.94%; in the MohalKhad Watershed and Parvati Watershed 20.93% and 8.51% respectively. The dominant species were *Quercus semecarpifolia, Aesculus indica,Prunus cornuta, Abies pindrow, Pinus wallichiana, Picea smithiana* and *Cedrus deodara.*

Soil composition: pH of sites supporting *Taxus baccata* sub. sp. *wallichiana* in the Upper Banjar Valley ranged from 4.76-6.57; Moisture Content, 10.82-46.71%; Carbon, 1.44-7.57% and Nitrogen, 0.07-1.68%; in the Mohal Khad Watershed pH, 6.39; Moisture Content, 26.88%; Carbon, 6.33% and Nitrogen, 2.38%; and in the Parvati Watershed pH, 7.33; Moisture Content, 19.87%; Carbon, 1.63% and Nitrogen, 1.87%.

16. *Valeriana jatamansii*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Banjar Valley, this species was represented in 07 sites; Mohal Khad Watershed, 08 sites; and in the Parvati Watershed, 03 sites. The relative density of the species, In the Upper Banjar Valley, ranged from 0.31-9.79%; in the Mohal Khad Watershed from 1.67-5.42%; and in the Parvati Watershed, from 3.19-6.60%. The dominant species were *Abies pindrow, Aesculus indica, Quercus leucotrichophora, Cedrus deodara, Prunus cornuta, Acer acuminatum, Pinus wallichiana* and *Picea smithiana.*

Soil composition: pH of sites supporting *Valeriana jatamansii* in the Upper Banjar Valley ranged from 5.13-7.13; Moisture Content, 19.77-48.25%; Carbon, 1.28-7.46% and Nitrogen, 0.70-2.10%; in the Mohal Khad Watershed, pH from 5.3-7.63; Moisture Content, 26.44-53.54%; Carbon, 2.60-6.37% and Nitrogen, 1.56-2.38%; and in the Parvati Watershed, pH from 6.12-7.33; Moisture Content, 7.50-19.87%; Carbon, 1.63-4.73% and Nitrogen, 1.20-2.10%.

Table 1: Site wise Density, Total Basal Area (TBA), Diversity and concentration of Dominance (Cd) of trees shrubs and herbs in the study areas.

Upper Banjar Valley										
	Density (Ind ha^{-1}& *Ind m^{-2})			TBA (m^2 ha^{-1})	Diversity (H')			Concentration of Dominance (Cd)		
Site	Trees	Shrubs	*Herbs		Trees	Shrubs	Herbs	Trees	Shrubs	Herbs
1	960.00	2340.00	164.23	43.48	1.08	2.15	2.94	0.46	0.14	0.06
2	380.00	3180.00	106.65	105.95	0.53	1.60	3.11	0.76	0.28	0.05
3	470.00	2440.00	107.93	103.51	0.98	2.03	3.02	0.57	0.15	0.06
4	660.00	1980.00	124.93	42.80	0.29	1.60	3.01	0.88	0.24	0.07
5	1070.00	2630.00	94.78	79.78	0.68	1.60	2.92	0.51	0.22	0.07
6	330.00	3280.00	124.80	12.69	0.94	1.67	3.21	0.45	0.23	0.05
7	880.00	1380.00	85.65	77.39	1.11	1.52	2.74	0.35	0.25	0.08
8	510.00	860.00	98.68	31.22	1.34	1.10	2.65	0.31	0.33	0.09
9	40.00	3456.36	88.83	0.09	0.00	2.22	2.86	1.00	0.15	0.07
10	-	3050.00	90.28	-	-	1.75	3.14	-	0.20	0.06
11	810.00	1800.00	100.23	29.33	0.27	1.71	3.09	0.88	0.19	0.06
12	-	1490.00	93.65	-	-	2.18	2.92	-	0.13	0.09
13	470.00	1160.00	95.15	42.10	0.76	1.90	2.90	0.55	0.18	0.08
14	730.00	1440.00	89.10	79.55	1.12	1.61	2.61	0.35	0.23	0.09
15	720.00	1000.00	77.90	100.97	0.93	1.47	2.52	0.43	0.28	0.09
16	660.00	600.00	52.83	92.91	0.78	1.74	2.32	0.52	0.20	0.11

17	410.00	705.45	96.35	104.07	0.00	1.02	3.20	1.00	0.47	0.06
18	140.00	1570.00	83.98	11.65	1.06	1.97	2.67	0.36	0.17	0.10
19	510.00	1100.00	91.03	39.27	1.37	1.43	2.88	0.29	0.30	0.08
20	440.00	1690.00	108.68	44.22	1.60	1.83	3.05	0.24	0.19	0.06
21	970.00	1531.82	106.98	41.57	1.13	1.79	2.87	0.40	0.20	0.08
22	260.00	1630.00	80.50	71.20	1.73	2.36	3.01	0.23	0.12	0.06
23	360.00	1190.00	81.33	35.54	0.62	2.04	2.86	0.71	0.16	0.07
24	450.00	1200.00	97.38	45.20	0.87	1.86	2.84	0.50	0.23	0.07
25	350.00	2119.19	71.51	32.90	0.62	1.34	2.95	0.66	0.38	0.06
26	530.00	2873.53	62.92	50.40	1.37	1.43	2.68	0.29	0.30	0.08
27	360.00	1840.00	97.43	54.70	0.98	2.27	3.19	0.41	0.12	0.05
Mohal Khad Watershed										
1	490.00	1280.00	71.70	31.56	1.31	2.38	3.20	0.37	0.10	0.06
2	560.00	2980.00	68.65	37.19	1.37	2.49	3.31	0.32	0.09	0.06
3	410.00	3380.00	74.90	48.55	0.56	2.86	3.53	0.74	0.07	0.04
4	120.00	2040.00	58.03	41.66	0.68	2.73	3.35	0.51	0.07	0.04
5	350.00	740.00	82.00	29.78	1.53	1.66	3.18	0.23	0.25	0.06
6	380.00	3560.00	81.18	38.70	0.63	2.62	3.17	0.65	0.09	0.06
7	540.00	2490.00	74.30	46.54	1.34	2.64	2.82	0.37	0.09	0.07
8	460.00	1870.00	138.73	42.05	2.04	2.68	3.31	0.15	0.09	0.05
9	430.00	2110.00	82.98	40.83	0.51	2.73	3.40	0.67	0.07	0.06
Parvati Watershed										
1	171.00	900.00	48.28	34.75	0.71	2.17	2.54	0.51	0.10	0.11
2	40.00	520.00	31.63	3.84	0.56	2.03	2.21	0.63	0.15	0.18
3	240.00	940.00	39.60	11.03	1.18	1.83	2.74	0.37	0.21	0.08
4	110.00	740.00	35.75	9.06	0.60	1.87	2.75	0.69	0.17	0.08
5	130.00	1050.00	57.08	16.70	1.06	2.83	2.64	0.36	0.08	0.10
6	480.00	970.00	49.00	51.64	1.50	2.26	2.88	0.26	0.09	0.07
7	320.00	860.00	52.73	75.78	0.59	2.16	2.52	0.60	0.10	0.11
8	470.00	810.00	97.60	72.90	1.15	2.30	2.98	0.38	0.09	0.07

Table 2: Site wise pH, moisture content (%), total organic matter (%), total organic carbon (%), total nitrogen (%), and Carbon/Nitrogen ratio in the study areas.

Site No.	pH	MC	Om	OC	N	C/N
Upper Banjar Valley						
1	6.12	28.43	12.19	7.07	0.91	7.77
2	6.99	21.18	8.23	4.77	0.56	8.52
3	5.97	29.30	6.05	3.51	1.40	2.51
4	5.31	38.14	12.26	7.11	1.05	6.77
5	4.85	28.37	11.20	6.50	0.63	10.31
6	5.13	40.68	12.39	7.19	0.70	10.27
7	5.11	34.48	12.79	7.42	0.77	9.63
8	5.74	34.48	12.32	7.15	0.98	7.30
9	5.01	46.93	12.46	7.23	0.77	9.39
10	5.00	40.06	11.00	6.38	0.35	18.24
11	5.47	48.25	12.13	7.03	0.14	50.25
12	6.24	14.72	2.21	1.28	0.21	6.12
13	5.79	38.30	6.71	3.89	0.49	7.94
14	5.04	46.71	13.05	7.57	0.98	7.73
15	4.76	30.45	10.47	6.08	0.56	10.85
16	5.77	34.62	12.19	7.07	0.49	14.43
17	5.49	42.36	12.85	7.46	0.84	8.88
18	5.60	33.19	4.13	2.40	0.42	5.70

19	5.57	46.23	11.66	6.77	0.56	12.08
20	6.14	23.39	2.35	1.36	0.07	19.44
21	5.86	45.61	11.86	6.88	0.77	8.94
22	5.53	18.21	2.48	1.44	0.56	2.57
23	6.57	10.82	9.63	5.59	1.68	3.33
24	6.76	20.82	10.97	6.36	1.68	3.79
25	6.18	19.77	5.82	3.38	1.78	1.90
26	7.13	22.19	6.76	3.92	2.10	1.87
27	7.20	18.92	9.57	5.55	0.56	9.91
Parvati Watershed						
1	6.98	7.50	8.16	4.73	1.20	3.94
2	5.89	14.32	3.14	1.82	1.68	1.08
3	6.13	7.11	1.94	1.13	1.87	0.60
4	6.76	25.98	10.71	6.21	2.43	2.56
5	5.43	11.02	2.74	1.59	2.00	0.80
6	6.12	18.84	5.95	3.45	2.10	1.64
7	6.15	15.09	8.70	5.05	2.33	2.17
8	7.33	19.87	2.81	1.63	1.87	0.87
Mohal Khad Watershed						
1	7.63	26.44	6.82	3.96	1.68	2.36
2	5.63	34.36	14.76	6.40	2.37	2.70
3	6.09	44.65	6.82	3.96	1.56	2.54
4	6.81	29.08	8.30	4.81	2.15	2.24
5	6.20	28.64	5.02	2.91	2.15	1.35
6	6.17	29.31	4.48	2.60	2.04	1.27
7	5.05	39.17	6.56	3.80	2.04	1.86
8	5.33	53.54	11.37	6.60	2.45	2.69
9	6.39	26.88	12.71	6.37	2.38	2.68

Abbreviation used: *MC=Moisture content, TN=Total nitrogen, OC=Total organic carbon, OM=Total organic matter and C/N=Carbon/Nitrogen.*

Table 3: Physical characteristics, dominant species and occurrence of threatened medicinal plants within the study areas.

Site No.	Altitude (m)	Habitat	Slope (^{0})	Aspect	Latitude	Longitude	Dominant species	Occurrence of Threatened Medicinal Plants
1	2160	SM	60	NW	31^0 34.216' N	$77^0$21.835' E	*Pinus wallichiana, Picea smithiana*	*Paris polyphylla, Valeriana jatamansii*
2	2056	R	65	W	$31^0$34.394 'N	$77^0$21.746' E	*Aesculus indica, Picea smithiana*	*Rhododendron arboreum, Bergenia ciliata, Diascorea deltoidea, Valeriana jatamansii*
3	2295	SM	55	SW	31^0 33. 620' N	77^0 22.043'E	*Picea smithiana, Ilex dipyrena*	*Diascorea deltoidea, Polygonatum verticillatum,*
4	3135	SM	60	NE	31^0 32.356' N	77^0 22.168' E	*Quercus semecarpifolia, Prunus cornuta*	*Rhododendron campanulatum, Podophylum hexandrum, Polygonatum verticillatum, Valeriana jatamansii*
5	3113	SM	75	E	31^0 32.125' N	77^0 21.612' E	*Quercus semecarpifolia, Taxus baccata*	*Taxus baccata, Podophylum hexandrum*

6	3153	SM	65	NW	31^0 32.078' N	77^0 21.600' E	*Prunus cornuta, Quercus semecarpifolia, Acer acuminatum*	*Rhododendron campanulatum, Angelica glauca, Polygonatum verticillatum, Valeriana jatamansii*
7	3084	Dg	55	W	31^0 32.253' N	77^0 21.843' E	*Quercus semecarpifolia, Taxus baccata, Abies pindrow*	*Taxus baccata,*
8	3083	SM	50	N	31^0 32.287' N	77^0 21.930' E	*Acer acuminatum, Prunus cornuta, Taxus baccata*	*Taxus baccata, Valeriana jatamansii*
9	3245	SM	55	N	31^0 32.209' N	77^0 22.697' E	*Prunus cornuta*	*Rhododendron campanulatum, Berberis aristata, Angelica glauca, Podophylum hexandrum, Polygonatum verticillatum*
10	3275	Shr	50	NW	31^0 32.292' N	77^0 23.050' E	*Rhododendron campanulatum, Salix denticulata*	*Rhododendron campanulatum, Berberis aristata, Angelica glauca, Podophylum hexandrum, Polygonatum verticillatum*
11	3145	SM	65	N	31^0 32.339' N	77^0 22.821' E	*Prunus cornuta, Acer acuminatum, Quercus semecarpifolia*	*Rhododendron campanulatum, Angelica glauca, Polygonatum verticillatum, Valeriana jatamansii*
12	3080	Ro	80	W	31^0 32.331' N	77^0 22.699' E	*Viburnum cotonifolium, Rosa webbiana*	*Rhododendron campanulatum, Bergenia ciliate, Polygonatum verticillatum, Valeriana jatamansii*
13	2970	R	50	NE	31^0 32.539' N	77^0 22.922' E	*Prunuscornuta, Acer acuminatum*	*Rhododendron campanulatum, Angelica glauca, Valeriana jatamansii*
14	3080	SM	35	NW	31^0 33.066' N	77^0 22.928' E	*Abies pindrow, Taxus baccata, Quercus semecarpifolia*	*Taxus baccata, Podophylum hexandrum, Polygonatum verticillatum*
15	3065	SM	50	S	31^0 32.765' N	77^0 23.021' E	*Abies pindrow, Taxus baccata*	*Taxus baccata, Bergenia ciliata, Polygonatum verticillatum*
16	3014	Dg	40	SW	31^0 32.611' N	77^0 22.960' E	*Abies pindrow, Taxus baccata*	*Taxus baccata*
17	2854	SM	30	NW	31^0 33.105' N	77^0 22.556' E	*Abies pindrow*	*Berberis aristata, Angelicaglauca, Podophylum hexandrum, Polygonatum verticillatum, Valeriana jatamansii*
18	2530	Dg	40	W	31^0 33.571' N	$77^0$22.286 ' E	*Picea smithiana, Rhus semialata*	*Angelica glauca*
19	2554	SM	30	SW	31^0 33.114' N	77^0 22339' E	*Abies pindrow, Prunus cornuta, Juglans regia*	
20	2639	R	50	W	31^0 32.879' N	77^0 22' 409'E	*Abies pindrow, Taxus baccata, Prunus cornuta*	*Taxus baccata*
21	2758	SM	20	N	31^0 32917' N	77^0 22.502' E	*Acer acuminatum, Prunus cornuta, Juglans regia*	*Diascorea deltoidea, Podophylum hexandrum*
22	1945	SM	10	SE	$31^0$34.637 ' N	$77^0$21.616 'E	*Picea smithiana, Cedrus deodara,*	*Paris polyphylla*
23	1990	SM	20	E	$31^0$34.637 ' N	$77^0$21.616 'E	*Cedrus deodara*	*Taxusbaccata*
24	2020	SM	40	NE	$31^0$34.407 ' N	$77^0$21.925 'E	*Persea duthiei, Picea smithiana*	*Paris polyphylla*
25	1986	SM	35	W	$31^0$34.152	$77^0$21.779	*Persea duthiei, Picea*	*Paris polyphylla, Polygona-*

					' N	'E	*smithiana*	*tum multiflorum, Valeriana jatamansii*
26	2110	SM	25	N	$31^0$34.501 ' N	$77^0$22.357 'E	*Picea smithiana, Persea duthiei*	*Paris polyphylla, Polygonatum verticillatum, Valeriana jatamansii*
27	2190	SM	20	NE	$31^0$34.240 ' N	$77^0$22.736 'E	*Picea smithiana, Aesculus indica*	*Paris polyphylla, Diascorea deltoidea*
Mohal Khad Watershed								
1	1738	SM	10	SW	$31^0$51.721 ' N	$77^0$05.193 'E	*Pinus wallichiana, Quercus leucotrichophora*	*Paris polyphyla*
2	1757	SM	15	SW	$31^0$51.673 ' N	$77^0$04.920 'E	*Persea duthiei, Quercus gulaca*	*Paris polyphyla*
3	1808	SM	10	SW	$31^0$51.458 ' N	$77^0$05.264 'E	*Persea duthiei*	*Paris polyphyla*
4	1905	SM	20	NW	$31^0$51.907 'N	$77^0$05.878 'E	*Picea smithiana, Juglens regia*	*Paris polyphyla*
5	2070	SM	25	NW	$31^0$51.850 ' N	$77^0$05.608 'E	*Picea smithiana, Aesculus indica*	*Paris polyphyla*
6	1450	Shr	5	E	$31^0$53.358 ' N	77° 05.083'E	*Pinus wallichiana, Cedrus deodara*	*Zanthoxylum armatum*
7	1856	SM	20	SW	$31^0$52.614 ' N	77° 04.178'E	*Picea smithiana, Cedrus deodara*	*Paris polyphyla*
8	1760	SM	15	SW	31°52.813' N	77°04.465'E	*Picea smithiana, Persea duthiei*	*Paris polyphyla*
9	2900	SM	15	NW	$31^0$50.256 ' N	77^0 04.663'E	*Abies pindrow*	*Taxus baccata*
Parvati Watershed								
1	2182	Ro	55	NW	$32^0$00'02" N	$77^0$27' 08"E	*Picea smithiana, Pinus wallichiana*	*Angelica galuca*
2	2213	Dg	30	E	$31^0$59'58" N	$77^0$26' 54"E	*Hippophae salicifolia, Salix alba*	*Hippophea salicifolia*
3	2049	SM	20	W	$32^0$00'19" N	$77^0$24' 26"E	*Pinus wallichiana, Salix alba*	*Hippophea salicifolia*
4	2136	SM	15	SE	$32^0$00'04" N	$77^0$25' 42"E	*Hippophae salicifolia, Salix alba*	*Hippophea salicifolia*
5	1919	R	10	SE	$31^0$58'41" N	$77^0$19' 56"E	*Hippophae salicifolia*	*Hippophea salicifolia*
6	2133	SM	20	W	$31^0$59'33" N	$77^0$19' 51"E	*Cedrus deodara, Picea smithiana*	*Angelica galuca*
7	2440	SM	25	NW	$31^0$59'04" N	$77^0$20' 09"E	*Picea smithiana, Cedrus deodara*	*Angelica galuca*
8	2520	SM	25	NW	$31^0$59.741 'N	$77^0$22.663 'E	*Picea smithiana, Abies pindrow*	*Taxus baccata*

Abbreviations used: *SR=Site representation, SM=shady moist, R= riverine, Ro= Rocky, Dg= Degraded, Shr=Shrubbery, S=South, N=North, E=East, W=West, SW=South West, SE=South East, EW=East West and NW=North West*

17. *Zanthoxylum armatum*

Altitude, slope, aspect, habitat, latitude and longitude were presented in Table 1. In the Mohal Khad Watershed this species was represented in 02 sites. The relative density of the species, In the Mohal Khad Watershed, ranged from 2.67-3.65%. The dominant species were *Cedrus deodara, Pinus wallichiana* and *Picea smithiana.*

Soil composition: pH of sites supporting *Zanthoxylum armatum* in the Mohal Khad Watershed ranged from 5.33-6.17; Moisture Content, 29.31-53.54%; Carbon, 2.60-6.60% and Nitrogen, 1.04-2.45%.

Discussion: Indian Himalayan region is well known for its diversity of Medicinal plants and 1748 species have been recorded. However, studies on population assessment of threatened medicinal plants in particu-

larly are not available. Therefore, the present study provides comprehensive site/location specific information on diversity, distribution, habitat, soil composition and density of medicinal plants in the study area. Regular monitoring of the populations and habitats of threatened medicinal plants using ecological methods have been suggested. In addition, identification of active ingredients would help identifying the potential species for marketing. Mass multiplication of the commercially viable medicinal plants through conventional and *in-vitro* methods, establishment of these species in natural habitats and *ex-situ* conditions mainly cultivation in marginal lands of the inhabitants and capacity building of the inhabitants for the cultivation and sustainable utilization of medicinal plants have been suggested. The state medicinal plant board and forest department may implement the above suggestions for the development of medicinal plant sector. Such type of studies are also required in other parts of the Indian Himalayan Region so that comprehensive database of medicinal plants could be developed and utilized in identification and notification of medicinal plant conservation areas and develop location and region specific management plan.

CONCLUSION: An area specific threat categorization of species is most important for short or long term management planning. The present study represents such an approach in this area, using information on different attributes. Cultivation of such medicinal plants in the surrounding villages and other private lands may condense the extinction pressure on the wild habitats. Identification of active ingredients would help identifying the potential species for marketing. Regular populations and habitats monitoring of native, endemic and threatened medicinal plants using ecological methods and notification of key areas as medicinal plants conservation areas (MPCAs) for *in situ* conservation, with the involvement of the State Forest Department and inhabitants of the area have been suggested. Besides these, mass reproduction using conventional methods, establishment and maintenance of herbal gardens and medicinal plant nurseries for ex situ conservation and ensuring the availability of quality planting material for cultivation, together with education and awareness programmes for large scale cultivation area recommended.

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