

Threat Categorization and Conservation Prioritization of Medicinal Plants in the Surroundings of Different Hydro-electric Projects of Kullu District in Himachal Pradesh, India

Pankaj Sharma^{1*} and S. S. Samant²

¹Himachal Pradesh State Biodiversity Board, H.P. State Council for Science, Technology & Environment, Vigyan Bhawan, Bemloe, Shimla-171001, Himachal Pradesh, INDIA

²G.B. Pant National Institute of Himalayan Environment & Sustainable Development, Himachal Unit, Mohal-Kullu-175 126, Himachal Pradesh, INDIA

* Correspondence: E-mail: spankaj80@gmail.com

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ABSTRACT: The diversity of life exists on earth and each life form has its own needs for existence. Greater biodiversity leads to greater productivity and greater nutrient retention in ecosystem which leads to greater ecosystem stability. Mountains are home to some of the world's most threatened and endemic species (including medicinal plants), as well as to some of the poorest people, who are dependent on the biological resources. Keeping this in view, the present study has been conducted to study the threat categorization and conservation prioritization of medicinal plants in different hydro-electric projects of Kullu district in Himachal Pradesh, India. A total of 189 species (35 Trees; 38 Shrubs; 94 Herbs and 22 Ferns) of medicinal plants belonging to 139 genera and 83 families have been identified as threatened from the different Hydro-electric Projects (HEPs) areas. Highest medicinal plants were reported in the altitudinal zone, 1801- 2800 and decreased with increasing or decreasing altitude in the study area. An area-specific threat categorization of species is very essential for short or long term management planning. In present study such an effort in the study area, using information on different attributes was initiated. The over-exploitation, habitat degradation and changing environmental conditions may lead to the extinction within a few years. Therefore, regular monitoring of population and habitats, development of conservation protocol, establishment of species in-situ conditions and associated habitats and replication of this approach in other parts of Indian Himalayan Region have been recommended. So that the gene pool of this unique group of plants could be maintained posterity.

Keywords: Threat Categorization; Conservation Prioritization; Medicinal Plants; Hydroelectric Project and Himachal Pradesh.

INTRODUCTION: Global biodiversity is being lost at an unprecedented rate, as a consequence of human induced environmental change¹. Since 1966 the International Union for Conservation of Nature and Natural Resources (IUCN) has evaluated species conservation status worldwide and today the IUCN Red Lists have become one of the most important information sources about the conservation status of world's flora and fauna worldwide. Evaluating species conservation status is one of the main tools for establishing conservation priorities and management policies². A species global conservation status, however, is not necessarily the same as the conservation status on a regional scale. Some species that are threatened on a global scale may not be threatened on a regional scale, and species that are not threatened on a global scale might

be threatened in some part of their range³. Some species may be declining fast across their ranges on average but may be locally stable or even increasing. Moreover, knowing the regional status of species is important for several reasons. Loss of population and genetic diversity is a major concern⁴. When a species is protected on a regional scale, conservation of its genetic diversity is promoted⁵. The extinction of a species is the result of local extinctions of its populations⁶. Clearly, conservation is in need of a method for the assessment of conservation priorities with small data demands, which combines the advantages of red lists and the assessment of international importance of a population⁷. Degradation and fragmentation of >70% of the original habitats placed Himalaya in the list of Global Biodiversity Hotspots⁸. Under the cur-

rent scenario, about 20% of all species are expected to be lost within 30 years and 50% or more by the end of 21st century⁹.

In the IHR, over exploitation and habitat degradation are the two major factors responsible for decrease in population of the species¹⁰. In view of the ongoing threats, it is important to identify and prioritize biodiversity elements at local, regional and global levels. As such, threat assessment of all the species of a particular region has been carried out by a very few workers¹¹. Such studies are essentially required along the altitudinal and across the horizontal gradients of the IHR. Therefore, present attempt has been made to assess the threat categories of species in different HEPs areas and suggest conservation options.

MATERIALS AND METHODS:

Study Area: The present study has been conducted in three different hydroelectric projects (HEPs), i.e., Saini Hydro-Electric Project (Sainj HEP) (Latitudes 31°45'45" to 31°50'16" N and Longitudes 77°18'33" to 77°24'05" E) is 100 Mega Watt (MW) and the total area covered 0.96 km²; Parbati Hydro-Electric Project Stage II (PHEP Stage II) (Latitudes 31°45' 52" to 32°00'20" N and Longitudes 77°18'30" to 77°28'15" E) is 800 MW and the total area covered 2.18 km²; and Malana II Hydro-Electric Project (Malana II HEP) (Latitudes 32°02'36" to 32°05'51"N and 77°14'23" to 77°17'36"E Longitudes) is 100 MW and the total area covered 0.035 km² in dam and submergence areas which also covers forest, non-forests and private land in Kullu district of Himachal Pradesh (Figure 1). The district is bounded by Lahaul-Spiti and Kangra districts on north and North-East, Kinnaur and Shimla districts on its East and South-East and one of the richest district in terms of biodiversity and supports one National Park (i.e., Great Himalayan National Park) and six Wildlife Sanctuaries (i.e., Manali, Kanawar, Khokhan, Kais, Sainj and Tirthan). These areas are very well known for their diverse habitats, microclimatic conditions and rich biodiversity including flora and fauna. The vegetation mainly comprises of sub-tropical, temperate, subalpine and dominated by broad leaved and coniferous forests. These areas support a large number of sensitive biodiversity elements including wild edibles, medicinal, native, endemic, rare endangered and wild relatives of crop plants. Climatically the area is unique, the temperature ranges between -7°C to 39°C.

Selection of Sites and Habitats for Vegetation

Sampling: Sites were selected on each and every accessible aspect between 1400m to 2600m amsl in Sainj HEP; 1300m to 2300m amsl in Sainj, 1400m to

2600m amsl in Barsaini and 1700m to 2500m amsl in Gadsa areas of Parbati HEP Stage II and 1800-3400m amsl in Malana valley of Malana II HEP. The habitats were identified based on the physical characters and dominance of the vegetation. The sites facing high anthropogenic pressure were considered as degraded habitats and sites having closed canopy with high percent of humus and moisture were considered as moist habitat whereas low percent of the same as dry habitat. The site having >50% boulders of the ground cover were considered as bouldary habitat. Latitudes, longitudes and altitude were measured with the help of Global Positioning System (GPS) and slope with the help of Abney's Level.

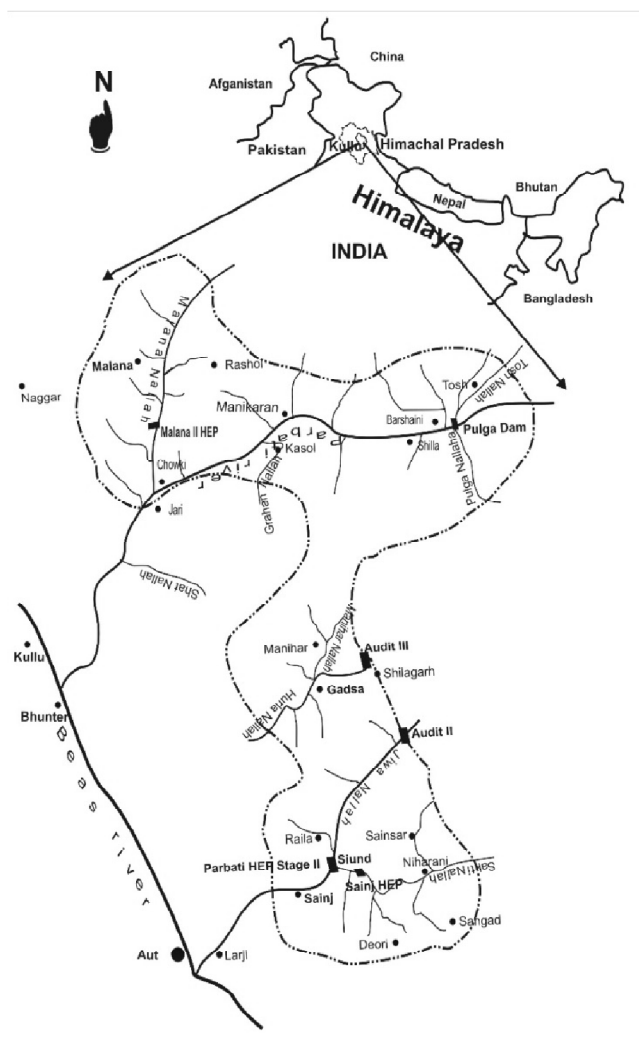


Figure 1: Study Area.

Survey, Sampling, Identification and Analysis of

Data: The field surveys were conducted during the July to September within the selected sites habitats for the quantitative assessment of vegetation. In each site, a plot of 50x50m was laid. Trees, saplings and seedlings were sampled by randomly laid 10, 10x10m quadrates; shrubs by 20, 5x5m quadrates and herbs by

20, 1x1m quadrat. For the collection of data from these quadrats standard ecological methods were followed¹². The circumference at breast height (cbh at 1.37m from ground) for each tree individual was recorded. The individuals with (cbh \geq 31.5 cm), were considered as trees, (cbh 10.5-31.4 cm) saplings and (cbh <10.5 cm) seedlings. Samples of each species were collected from each site and identified with the help of florulas and research papers.

Different attributes such as habitat specificity, population size, distribution range, use values, extraction, nativity and endemism of the taxa have been used for the threat categorization of the floristic diversity¹³. The attributes used were divided into three grades;

highest (10 marks); subsequent (6 marks) and least (2 marks). The species fulfilling all the attributes in highest grade resulted in highest cumulative values and one which falls in least grade for every attribute resulted in least cumulative values. The species having >70% score were considered as Critically Endangered; 60-69% as Endangered; 50-59% as Vulnerable; and 40-49% as Near threatened, whereas <45% were considered as Least Concern. Categorization of these species for the State and globally as Critically Endangered, Endangered, Vulnerable, *etc.*, has also been done^{10,13}. The species, which occurred in the area but not cited in the sampled sites have also been considered for categorization.

Table 1: Parameters used for the threat categorization of floristic diversity.

Parameters						
Points/ Scores	Altitudinal Range (m)	H/ Hs	Use Values	Population Size	Native and Endemic	Extraction
10	<500	2	> 4	250 Ind/2 locations	Native and Endemic	Commercial
6	500-1000	3-4	3-4	1000 Ind/3-5 location	Native/Endemic	Self Use
2	>1000	>4	<3	>1000 Ind/>5 locations	Non-native	No Extraction

Abbreviations Used: H/Hs=Habitat/(s); and m=Meter

RESULTS AND DISCUSSION:

Diversity of threatened species: Of the total species recorded, 189 species (35 Trees; 38 Shrubs; 94 Herbs & 22 Ferns) belonging to 139 genera and 83 families have been identified as threatened from the different HEPs areas (i.e., 119 species from Sainj HEP area; 98 species from Sainj area, 108 species from Barsaini area and 104 species from Gadsa area of Parbati HEP Stage II and 159 species from Malana II HEP). Sixty (60) species have been found to be Near Threatened. The remaining species fall under the Least Concern category.

Altitudinal distribution: Along an altitudinal gradient, the maximum rare endangered species (91 spp.) were distributed in 1801-2800m zone, followed by 1300-1800m (87 spp.) zone and >2800m (11 spp.) zone (Figure 2).

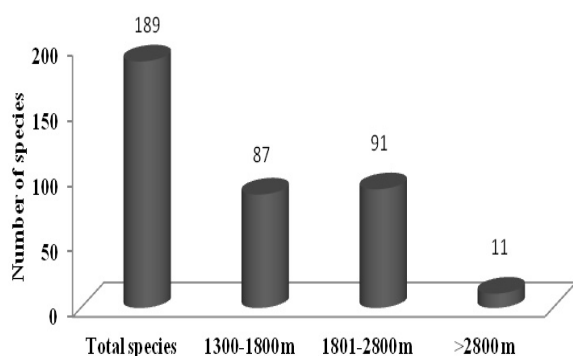


Figure 2: Altitudinal distribution of threatened plants in the selected HEPs areas.

Site and Habitat wise distribution: Site wise distribution of the threatened species indicated that 21 species were represented in one site only, 18 species in two sites whereas 49 species in 3 or >3 sites. 11 species have not been represented in any of the sampling sites. 142 species were reported from the forest, 99 species in riverine/watercourse, 97 species in shady moist, 84 species degraded, 55 species in dam submergence, 54 species in bouldary, 40 species in dry, 16 species in rocky, 12 species, each in waste place/roadside and near crop field/orchards and 10 species in landslide areas. Habitat wise distribution of species in the study area showed that 06 species were distributed in one habitat only, 47 species in two habitats, whereas 136 species were distributed in 3 or >3 habitats.

Threat Categorization: In the present study, of the total species, 16 species were identified as Critically Endangered, 28 species as Endangered; 85 species as Vulnerable; 60 species as Near Threatened and remaining species as Least Concern based on threat categorization score. Also using new IUCN criteria, 03 species have been categorized as Critically Endangered; Endangered (09 spp.); Vulnerable (10 spp.) for Himachal Pradesh and total 05 species; Critically Endangered (01 spp.); Endangered (03 spp.) and Vulnerable (01 spp.) were under global threat categories, whereas 03 species i.e., *Berberis aristata* (Rare) and *Acer caesium* and *Dioscorea deltoidea* (Vulnerable) have been recorded in the Red Data Book of Indian Plants¹⁴⁻¹⁶ (Table 2).

Nativity and Endemism: In general, in the selected HEPs (Sainj, Parbati Stage II and Malana II), of the total 189 threatened species, 124 species were native to the Himalayan Region, remaining species were non-natives. 06 species were endemic and 65 species near endemic to the Indian Himalayan Region.

Table 2: Distribution, Threat categorization and status of medicinal plants in the surroundings of different hydro-electric projects of Kullu district in Himachal Pradesh, India.

Taxa	Family	Occurrence	AR (m)	Habitat /s	LF	Status			Threats
						HP	GB	RD	
Critically Endangered									
<i>Allium humile</i> Kunth.*	Alliaceae	E	2500-3400	7	H	-	-	-	OE, HD
<i>Pistacia integerrima</i> Stew.	Anacardiaceae	A, B, C, E	1700-2400	1, 3, 12	T	-	-	-	OE, HD
<i>Angelica glauca</i> Edgew.**	Apiaceae	A, B, C, D, E	1900-3300	1, 2	H	EN	EN	-	OE, HD
<i>Betula utilis</i> D. Don	Betulaceae	E	3000-3400	1, 3	T	EN	-	-	OE, HD
<i>Juniperus indica</i> Bertol.	Cupressaceae	E	2700-3400	5	Sh	-	-	-	HD
<i>Hippophae salicifolia</i> D. Don	Elaeagnaceae	D, E	2200-2600	2, 3, 4, 8, 12	T	-	-	-	OE, HD
<i>Rhododendron anthopogon</i> D. Don*	Ericaceae	E	3000-3400	4, 7	Sh	VU	-	-	HD
<i>R. campanulatum</i> D. Don*	Ericaceae	E	2800-3400	4, 5, 7	Sh	VU	-	-	OE, HD
<i>Lilium polyphyllum</i> D. Don ex Royle*	Liliaceae	D, E	2100-2600	1, 3	H	CR	-	-	HD
<i>Paris polyphylla</i> Sm.	Liliaceae	A, B, C, D, E	1900-2700	1, 5	H	EN	-	-	HD
<i>Dactylorhiza hatagirea</i> (Don) Soo*	Orchidaceae	E	2600-3400	3	H	CR	-	-	OE, HD
<i>Malaxis muscifera</i> (Lindl.) Kuntz.	Orchidaceae	B, E	1500-3400	1, 3	H	-	-	-	HD
<i>Plantago himalaica</i> Pilger**	Plantaginaceae	E	2800-3200	5, 7	H	EN	EN	-	OE, HD
<i>Podophyllum hexandrum</i> Royle	Podophyllaceae	A, D, E	2300-3400	1, 3	H	-	-	-	HD
<i>Aconitum heterophyllum</i> Wall. ex Royle*	Ranunculaceae	E	2900-3400	1, 7	H	CR	CR	-	OE, HD
<i>Taxus baccata</i> L. subsp. <i>wallichiana</i> (Zucc.) Pilger	Taxaceae	C, D, E	2000-3300	1, 2, 3	T	EN	-	-	OE, HD
Endangered									
<i>Acer caesium</i> Wall. ex Brandis*	Aceraceae	A, C, D, E	2000-3000	1, 2, 6	T	-	-	VU	OE, HD
<i>Acorus calamus</i> L.	Acoraceae	A, B, C, D, E	2000-3000	1, 2, 6	T	-	-	-	OE, HD
<i>Allium thomsonii</i> Bak.	Alliaceae	E	2000-3400	7	H	-	-	-	OE, HD
<i>A. wallichii</i> Kunth	Alliaceae	E	2500-3400	1, 7	H	-	-	-	OE, HD
<i>Heracleum candicans</i> Wall. ex DC.	Apiaceae	A, B, C, D, E	1700-3000	1, 3, 12	H	VU	-	-	OE, HD
<i>Aralia cachemirica</i> Decne*	Araliaceae	A, B, C, D, E	1400-3200	1, 2, 3, 7, 12	H	-	-	-	OE, HD
<i>Inula grandiflora</i> Willd.*	Asteraceae	E	2000-3300	1, 2	H	-	-	-	HD
<i>Saussurea piptathera</i> Edgew.*	Asteraceae	E	2100-2500	2, 3, 6	H	-	-	-	HD

Taxa	Family	Occurrence	AR (m)	Habitat /s	LF	Status			Threats
						HP	GB	RD	
<i>Senecio chenopodifolius</i> DC.	Asteraceae	E	2400-3400	1, 5, 7	H	-	-	-	HD
<i>Berberis aristata</i> DC.*	Berberidaceae	A, B, C, D, E	1700-3200	1, 2, 5, 7, 12	Sh	EN	-	R	OE, HD
<i>B. asiatica</i> Roxb. ex DC.	Berberidaceae	A, B	1900-2400	1, 2, 3	Sh	-	-	-	HD
<i>B. chitria</i> Ed.	Berberidaceae	A, B, E	2100-3000	4, 7	Sh	-	-	-	HD
<i>B. jaeschkeana</i> Schneid.*	Berberidaceae	E	2600-3400	1, 7	Sh	-	-	-	HD
<i>Stellaria patens</i> D.Don*	Caryophyllaceae	C	2200-2500	3, 7	H	-	-	-	HD
<i>Corylus jacquemontii</i> Decne*	Corylaceae	A, C, D, E	1800-3000	1, 2, 12	T	-	-	-	OE, HD
<i>Dioscorea deltoidea</i> Wall. ex Kunth	Dioscoreaceae	A, B, C, D, E	1300-2800	1, 2, 3, 12	H	EN	EN	VU	OE, HD
<i>Rhododendron arboreum</i> Sm.	Ericaceae	A, B, C, D, E	1600-2700	1, 2, 3, 4, 12	T	-	-	-	OE
<i>Gentianella moorcroftiana</i> (Wall. ex G. Don) Airy Shaw*	Gentianaceae	E	2700-3400	1, 5, 7	H	-	-	-	HD
<i>Thymus linearis</i> Benth.	Lamiaceae	A, B, D, E	1800-2600	3, 4, 5, 12	H	-	-	-	OE, HD
<i>Morina longifolia</i> Wall. ex DC.*	Morinaceae	E	2500-3400	1, 3, 5	H	-	-	-	HD
<i>Olea ferruginea</i> Royle	Oleaceae	A, B, E	1300-1900	1, 2, 4, 12	T	-	-	-	OE, HD
<i>Epipactis giganteum</i> Dougl. ex Hk.	Orchidaceae	D	2200-2600	1, 2, 3	H	-	-	-	HD
<i>E. heleborine</i> (L.) Crantz	Orchidaceae	A, C, D, E	2300-3400	1, 2, 3, 12	H	-	-	-	HD
<i>Goodyera repens</i> (L.) R.Br.	Orchidaceae	D, E	2200-3300	1, 2, 3	H	-	-	-	HD
<i>Habenaria edgeworthii</i> Hk.f. ex Collett*	Orchidaceae	A, B, C, D, E	1300-3300	1, 3	H	-	-	-	HD
<i>Symplocos chinensis</i> (Lour.) Druce	Symplocaceae	A, B, C	1500-2600	1, 4	T	-	-	-	HD
<i>Trillidium govanianum</i> (Wall. ex D. Don) Kunth.*	Trilliaceae	A, C, D, E	2100-3400	1, 2, 3	H	-	-	-	OE, HD
<i>Valeriana hardwickii</i> Wall.	Valerianaceae	A, B, C, D, E	1600-3200	1, 7	H	-	-	-	OE, HD
Vulnerable									
<i>Acer acuminatum</i> Wall. ex D.Don*	Aceraceae	A, B, D, E	1800-3000	1, 2, 4, 6	T	-	-	-	OE, HD
<i>A. cappadocicum</i> Gledt.	Aceraceae	A, B, C, E	1900-3000	1, 2, 12	T	-	-	-	HD
<i>Adiantum venustum</i> D. Don	Adiantaceae	A, B, C, D, E	1700-3000	1, 2, 3, 4	Fn	-	-	-	HD
<i>Allium victorialis</i> L.	Alliaceae	A, D, E	2300-3000	3, 4	H	-	-	-	OE, HD
<i>Selinum tenuifolium</i> Wall.*	Apiaceae	A, B, C, D, E	1700-3000	1, 2, 3, 7	H	-	-	-	HD
<i>Pleurospermum angelicoides</i> (DC.) Cl.	Apiaceae	D, E	2400-3400	1, 3, 7	H	-	-	-	HD
<i>Asplenium yoshinaga</i> Mak.	Aspleniaceae	A	2200-2600	1, 3, 5, 7	Fn	-	-	-	HD

Taxa	Family	Occurrence	AR (m)	Habitat /s	LF	Status			Threats
						HP	GB	RD	
<i>Athyrium rubricaula</i> (Bl.) Moore	Athyriaceae	E	2000-3300	1, 2, 7	Fn	-	-	-	HD
<i>A. rupicola</i> (Edgew. ex Hope) C. Chr.	Athyriaceae	C	2300-2500	2, 3	Fn	-	-	-	HD
<i>Buxus wallichiana</i> Baill.	Buxaceae	A, B, C, D, E	1800-2700	1, 2	T	-	-	-	HD
<i>Codonopsis rotundifolia</i> Benth.	Campanulaceae	E	2900-3400	3, 7	H	-	-	-	HD
<i>Leycesteria formosa</i> Wall.	Caprifoliaceae	A, B, C	1700-2600	1, 2, 7	Sh	-	-	-	OE, HD
<i>Lonicera myrtillus</i> Hk. f. Th.	Caprifoliaceae	D	2500-2600	3, 7	Sh	-	-	-	HD
<i>Viburnum nervosum</i> D. Don*	Caprifoliaceae	C, E	2400-3200	1, 7	Sh	-	-	-	HD
<i>Viburnum grandiflorum</i> Wall. ex DC.*	Caprifoliaceae	D, E	2000-3000	1, 2, 7, 12	Sh	-	-	-	OE, HD
<i>Arenaria festucoides</i> Benth.*	Caryophyllaceae	B, E	3000-3400	1, 7, 11	H	-	-	-	HD
<i>Minuartia kashmirica</i> (Edgew.) Matt.	Caryophyllaceae	E	2500-2800	1, 7	H	-	-	-	HD
<i>Cornus capitata</i> Wall.*	Cornaceae	A, B, C, D, E	1300-3000	1, 2, 12	T	-	-	-	OE, HD
<i>Rhodiola bupleuroides</i> (Wall. ex Hk.f. & Th.) S.H. Fu	Crassulaceae	E	3100-3400	5, 6, 7	H	-	-	-	HD
<i>Onychium fragile</i> Verma et Khullar	Cryptogram-maceae	A, B, C, D	1600-2500	1, 3, 8	Fn	-	-	-	HD
<i>Juniperus communis</i> L.	Cupressaceae	E	2200-3400	5	Sh	-	-	-	HD
<i>Cyrtomium caryotideum</i> (Wall. ex Hk. & Grev.) Presl.	Dryopteridaceae	A, B, C, D, E	1800-2500	1, 2, 11	Fn	-	-	-	HD
<i>Dryopteris panda</i> (Cl.) Christ.	Dryopteridaceae	A, E	2000-2700	1, 2, 3, 4	Fn	-	-	-	HD
<i>Polystichum nepalense</i> (Spreng.) C. Chr.	Dryopteridaceae	A, B, C	1800-2600	1, 2, 3	Fn	-	-	-	HD
<i>P. lachenense</i> (Hk.) Bedd.	Dryopteridaceae	E	2800-3400	1, 2, 5	Fn	-	-	-	HD
<i>Equisetum arvense</i> L.	Equisetaceae	A, B, C, D, E	2000-2600	1, 2, 11	Fn	-	-	-	HD
<i>Quercus floribunda</i> Lindl.*	Fagaceae	A, C, D, E	2000-2600	1, 2, 3	T	-	-	-	OE, HD
<i>Q. leucotricophora</i> A. Camus	Fagaceae	A, B, C, D, E	1400-2200	1, 3, 12	T	-	-	-	OE, HD
<i>Corydalis govaniana</i> Wall.*	Fumariaceae	E	2400-3400	5, 7, 7	H	-	-	-	HD
<i>Swertia angustifolia</i> Ham. ex D. Don	Gentianaceae	A, B, C, D, E	1800-3200	1, 2, 3	H	-	-	-	HD
<i>S. ciliata</i> (G. Don) Burt*	Gentianaceae	C, E	2400-3400	1, 2, 5, 7	H	-	-	-	HD
<i>Geranium wallichianum</i> D. Don ex Sw.*	Geraniaceae	A, B, C, D, E	1900-3400	1, 2, 3, 4, 5, 7	H	-	-	-	HD
<i>Ribes alpestre</i> Wall. ex Decne.	Grossulariaceae	A, B, D, E	1600-3000	1, 7, 12	Sh	-	-	-	HD
<i>Coniogramme fraxinea</i> (G. Don) Diels	Hemionitidaceae	A, C, D	1700-2500	1, 2, 3, 5	Fn	-	-	-	HD

Taxa	Family	Occurrence	AR (m)	Habitat /s	LF	Status			Threats
						HP	GB	RD	
<i>C. intermedia</i> Hieron. var. <i>glabra</i> Ching	Hemionitidaceae	A, D, E	1800-3000	1, 2, 5	Fn	-	-	-	HD
<i>Gymnopteris vestita</i> (Wall. ex Moore) Underw.	Hemionitidaceae	E	2000-2600	1, 5	Fn	-	-	-	HD
<i>Hypericum perforatum</i> L.	Hypericaceae	A, B, C, D, E	1300-2400	1, 8, 12, 10	H	VU	-	-	HD
<i>Juglans regia</i> L.*	Juglandaceae	A, B, C, D, E	1600-2900	1, 2, 3, 5, 12	T	-	-	-	OE, HD
<i>Lamium album</i> L.	Lamiaceae	C, D	2100-2600	3, 7, 4	H	-	-	-	HD
<i>Salvia lanata</i> Roxb.*	Lamiaceae	A, B, C, D, E	1500-3200	1, 3, 4, 10, 12	H	-	-	-	HD
<i>Polygonatum multiflorum</i> (L.) All.	Liliaceae	E	1800-2900	1, 2, 6	H	VU	-	-	HD
<i>Cardiocrinum giganteum</i> (Wall.) Makino	Liliaceae	A, B, C, D, E	1800-3100	1, 2, 11	H	-	-	-	HD
<i>Polygonatum cirrhifolium</i> (Wall.) Royle	Liliaceae	A, B, C, D, E	1900-3300	1, 7	H	EN	-	-	OE, HD
<i>Viscum album</i> L.	Loranthaceae	A, B, C, E	1800-2500	1, 2	Sh	-	-	-	HD
<i>Woodfordia fruticosa</i> (L.) Kurz.	Lythraceae	A, B	1500-2000	1, 2, 7	Sh	-	-	-	HD
<i>Toona ciliata</i> M. Roem.	Meliaceae	A, B, C	1600-2200	1, 2, 3, 12	T	-	-	-	HD
<i>Morus serrata</i> Roxb.*	Moraceae	A, B, C, E	1300-2800	1, 3, 12	T	-	-	-	OE, HD
<i>Fraxinus micrantha</i> Linglesh.**	Oleaceae	A, B, C, D, E	2000-2700	1, 2, 3	T	-	-	-	HD
<i>Ophioglossum petiolatum</i> Hk.	Ophioglossaceae	A, E	2100-2600	1, 2, 11	Fn	-	-	-	HD
<i>Herminium monorchis</i> (L.) R. Br.	Orchidaceae	E	2900-3300	1, 3	H	-	-	-	HD
<i>Orobancha alba</i> Steph. ex Willd.	Orobanchaceae	C, D, E	2300-3200	2, 7	H	-	-	-	HD
<i>Phytolacca acinosa</i> Roxb.	Phytolaccaceae	A, B, C, D, E	1600-2700	1, 2, 3, 5, 12	H	-	-	-	HD
<i>Stipa roylei</i> (Nees) Mez.*	Poaceae	C, D, E	2100-3200	3, 4, 5	H	-	-	-	HD
<i>Sinarundinaria falcata</i> (Nees) Chao & Renv.	Poaceae	A, B, C, D, E	1300-2800	1, 2, 6	Sh	-	-	-	HD
<i>Thamnocalamus spathiflorus</i> (Trin.) Munro*	Poaceae	A, B, D, E	2100-3300	1, 2, 12	Sh	-	-	-	HD
<i>Rheum australe</i> D. Don*	Polygonaceae	D, E	2300-3400	5, 6	H	-	-	-	OE, HD
<i>R. webbianum</i> Royle*	Polygonaceae	E	3100-3400	5, 6	H	VU	VU	-	OE, HD
<i>Drynaria mollis</i> Beddome	Polypodiaceae	A, E	2000-2600	1, 2, 7, 12	Fn	-	-	-	HD
<i>Lepisorus nudus</i> (Hk.) Ching	Polypodiaceae	A, D, E	2000-3300	1, 4, 5	Fn	-	-	-	HD
<i>Phymatopteris stracheyi</i> (Ching) P. Serm.	Polypodiaceae	A, C, D, E	2200-3200	1, 3, 7	Fn	-	-	-	HD
<i>Aquilegia pubiflora</i> Wall. ex Royle	Ranunculaceae	A, C, D, E	2000-3400	1, 2, 3, 4, 5	H	-	-	-	HD
<i>Clematis acuminata</i> DC.	Ranunculaceae	D, E	1800-2800	2, 3, 4, 5	Sh	-	-	-	HD

Taxa	Family	Occurrence	AR (m)	Habitat /s	LF	Status			Threats
						HP	GB	RD	
<i>C. barbellata</i> Edgew.*	Ranunculaceae	A, B, D, E	1900-3000	1, 2, 3, 4, 5, 12	Sh	-	-	-	HD
<i>C. buchananiana</i> DC.	Ranunculaceae	A, B, D, E	1300-3200	1, 2, 3, 5	Sh	-	-	-	HD
<i>C. roylei</i> Rehd.	Ranunculaceae	D	1700-2200	7, 8, 12, 11	Sh	-	-	-	HD
<i>C. montana</i> Buch.-Ham. ex DC.	Ranunculaceae	C	2200-2500	2, 3, 4, 5	Sh	-	-	-	HD
<i>Delphinium brunonianum</i> Royle	Ranunculaceae	E	2200-3400	1, 2, 3, 12	H	-	-	-	HD
<i>Delphinium denudatum</i> Wall. ex Hk. f. & Th.*	Ranunculaceae	A, B, C, D, E	2000-3300	1, 2, 3, 7, 12	H	-	-	-	HD
<i>D. vestitum</i> Wall. ex Royle*	Ranunculaceae	E	2600-3400	1, 2, 3, 5, 7	H	-	-	-	HD
<i>Potentilla fruticosa</i> L.	Rosaceae	C	2100-2500	3, 5	Sh	-	-	-	HD
<i>Skimmia laureola</i> Sieb. & Zucc. ex Walp.*	Rutaceae	A, C, D, E	2200-3100	1, 2	Sh	-	-	-	OE, HD
<i>Zanthoxylum armatum</i> DC.	Rutaceae	A, B, C, D, E	1500-2500	3, 4, 5, 12	Sh	EN	-	-	OE
<i>Meliosma dillenifolia</i> Walp.	Sabiaceae	C, E	1800-2600	1, 2, 3, 8	T	-	-	-	HD
<i>Houttuynia cordata</i> Thunb.	Saururaceae	E	1800-2600	1, 2, 11	H	-	-	-	HD
<i>Bergenia ligulata</i> Bletter.*	Saxifragaceae	A, B, C, D, E	1300-3400	1, 2, 5, 7	H	VU	-	-	OE
<i>B. stracheyi</i> (Hk. f. & Th.) Engl.*	Saxifragaceae	E	2700-3400	1, 2, 5	H	VU	-	-	OE
<i>Stegnogramma mollissima</i> (Kunze) Fras.-Jenk.	Thelypteridaceae	A, B, C	1800-2600	1, 2, 3, 12	Fn	-	-	-	HD
<i>Thelypteris palustris</i> (Salisb.) Schott.	Thelypteridaceae	B, C	1900-2600	1, 2, 3	Fn	-	-	-	HD
<i>Phymatopteris malacodon</i> (Hk.) P. Serm.	Thelypteridaceae	A, B, C	2100-2600	1, 3	Fn	-	-	-	HD
<i>Wikstroemia canescens</i> Meissn.**	Thymelaeaceae	A, B, C, D, E	1800-3000	1, 2, 3, 12	Sh	-	-	-	HD
<i>Ulmus villosa</i> Brand. ex Gamble*	Ulmaceae	A, B, C, D, E	1300-2700	1, 2, 10, 12	T	-	-	-	OE, HD
<i>U. wallichiana</i> Planch.	Ulmaceae	A, B, C	1500-2200	1, 2, 8, 12	T	-	-	-	OE, HD
<i>Valeriana jatamansi</i> Jones	Valerianaceae	A, B, C, D, E	1800-3400	1, 2, 3, 7	H	VU	-	-	OE
<i>Cissus repanda</i> Vahl	Vitaceae	A, B	1300-1800	1, 3, 2, 12	Sh	-	-	-	HD
<i>Hedychium spicatum</i> Sm.*	Zingiberaceae	A, B, C, D, E	1500-3000	1, 2, 3, 12	H	VU	-	-	OE
Near Threatened									
<i>Alangium chinense</i> (Lour.) Harms.	Alangiaceae	A, B, C, D	1500-2000	1, 2, 12	T	-	-	-	HD
<i>Rhus javanica</i> L.	Anacardiaceae	A, B, C, D, E	1500-2700	1, 2, 3, 5	T	-	-	-	HD
<i>R. wallichii</i> Hk. f.*	Anacardiaceae	A, B, C, E	1300-2500	1, 3	T	-	-	-	OE, HD
<i>Arisaema utile</i> Hk. f.**	Araceae	E	2200-3400	1, 2, 7	H	-	-	-	HD
<i>Marsdenia roylei</i> Wt.*	Asclepiadaceae	A, B, C, D, E	1300-2700	1, 2, 4, 6, 12	Sh	-	-	-	HD

Taxa	Family	Occurrence	AR (m)	Habitat /s	LF	Status			Threats
						HP	GB	RD	
<i>Adenocaulon himalaicum</i> Edgew.	Asteraceae	C, D, E	2400-3100	3, 7, 8	H	-	-	-	HD
<i>Inula cappa</i> (Buch.-Ham. ex D. Don) DC.	Asteraceae	A, B, D, E	1300-2000	1, 3, 4, 7	Sh	-	-	-	HD
<i>Saussurea albescens</i> (DC.) Sch.-Bip.**	Asteraceae	A, C, E	2200-3400	1, 3, 4, 7	H	-	-	-	HD
<i>S. deltoidea</i> (DC.) Sch.-Bip.	Asteraceae	E	3000-3400	1, 7	H	-	-	-	HD
<i>S. heteromalla</i> (D. Don) Hand.-Mazz.*	Asteraceae	A, C, D, E	2100-3000	1, 3, 7	H	-	-	-	HD
<i>Solidago virga-aurea</i> L.	Asteraceae	A, B, C, D, E	1700-3200	1, 3, 4	H	-	-	-	HD
<i>Taraxacum officinalis</i> Weber	Asteraceae	A, B, C, D, E	1700-3400	1, 2, 3, 5, 7, 11	H	-	-	-	HD
<i>Anaphalis cuneifolia</i> Hk. f.*	Asteraceae	D, E	2200-3400	3, 4, 5, 7, 11	H	-	-	-	HD
<i>Gnaphalium affine</i> D. Don	Asteraceae	A, B, D, E	1300-2700	1, 2, 3, 4, 5	H	-	-	-	HD
<i>Ligularia amplexicaulis</i> DC.*	Asteraceae	A, D, E	2400-3400	5, 6, 7	H	-	-	-	HD
<i>Impatiens amplexicaulis</i> Edgew.*	Balsaminaceae	A, C, D	2100-2600	1, 2, 3, 5, 6, 12	H	-	-	-	HD
<i>I. arguta</i> Hk.	Balsaminaceae	A, B, C, E	2000-2600	3, 4, 7	H	-	-	-	HD
<i>Betula alnoides</i> Buch.-Ham. ex D. Don	Betulaceae	A, B, C, D	1600-2600	1, 2, 5, 12	T	-	-	-	OE, HD
<i>Alnus nitida</i> (Spach) Endl.*	Betulaceae	A, B, C, D, E	1500-2500	1, 3, 4, 12	T	-	-	-	OE, HD
<i>Lindlofia longifolia</i> * (Benth.) Baill.	Boraginaceae	A, C, D, E	2200-3400	7	H	-	-	-	HD
<i>Silene cucubalus</i> Wibel	Caryophyllaceae	E	2100-3000	1, 12	H	-	-	-	HD
<i>Cornus macrophylla</i> Wall.	Cornaceae	A, B, C, D, E	1500-2700	1, 7, 12	T	-	-	-	OE, HD
<i>Carpinus viminea</i> Lindl.	Corylaceae	A, B, C, D, E	1800-2700	1, 2, 12	T	-	-	-	OE, HD
<i>Elaeagnus conferta</i> Roxb.*	Elaeagnaceae	A, B, C, D, E	1500-2500	1, 2, 12	Sh	-	-	-	OE, HD
<i>Euphorbia hirta</i> L.	Euphorbiaceae	A, B, C, E	1300-2500	1, 2, 3, 5	H	-	-	-	HD
<i>Astragalus chlorostachys</i> Lindl.*	Fabaceae	C, D, E	2300-3400	3, 6, 7, 7	H	-	-	-	HD
<i>Campylotropis stenocarpa</i> (Klotz.) Sch.*	Fabaceae	A, B	1300-2500	1, 2	Sh	-	-	-	HD
<i>Desmodium elegans</i> DC.	Fabaceae	A, B, C, D, E	1300-3000	1, 2, 3, 4, 5, 6, 12	Sh	-	-	-	OE, HD
<i>D. concinnum</i> DC.	Fabaceae	E	1800-2000	3, 8, 11	Sh	-	-	-	OE, HD
<i>Lespedeza gerardiana</i> Grah. ex Maxim.*	Fabaceae	A, B, D, E	1400-2600	3, 4	H	-	-	-	HD
<i>Gentiana carinata</i> (D. Don) Griseb.*	Gentianaceae	E	2000-3400	1, 7	H	-	-	-	HD
<i>Swertia cordata</i> Wall. ex Cl.*	Gentianaceae	A, C, D, E	2400-3400	1, 2, 3, 7	H	-	-	-	HD
<i>S. cuneata</i> D. Don*	Gentianaceae	C	2300-2500	5, 7	H	-	-	-	HD
<i>S. paniculata</i> Wall.*	Gentianaceae	A, B, C, D, E	1800-2700	4, 5, 7	H	-	-	-	HD

Taxa	Family	Occurrence	AR (m)	Habitat /s	LF	Status			Threats
						HP	GB	RD	
<i>S. petiolata</i> D. Don	Gentianaceae	E	2400-3400	1, 5, 7	H	-	-	-	HD
<i>Aesculus indica</i> Coleb. ex Wall.*	Hippocastanaceae	A, B, C, D, E	1600-2800	1, 2, 5, 12	T	-	-	-	OE, HD
<i>Hypericum elodeoides</i> Choisy	Hypericaceae	A, B, C, D, E	1800-3000	3, 8, 12	H	-	-	-	HD
<i>H. uralum</i> Buch.-Ham.	Hypericaceae	A, B, C, D, E	1300-3000	3, 5, 8	Sh	-	-	-	HD
<i>H. oblongifolium</i> Choisy*	Hypericaceae	A, B, C, D, E	2000-2800	3, 5, 8	Sh	-	-	-	HD
<i>Hypoxis aurea</i> Lour.	Hypoxidaceae	A, B, D, E	1400-2500	2, 6	H	-	-	-	HD
<i>Iris hookeriana</i> R. C. Fost.*	Iridaceae	A, B	2000-2600	1, 2, 3	H	-	-	-	HD
<i>Iris nepalensis</i> D. Don*	Iridaceae	A, B, D, E	1600-2800	3, 4	H	-	-	-	HD
<i>Neolitsea pallens</i> (D. Don) Momiyama & Hara	Lauraceae	A, B, C, D, E	1600-2600	1, 2, 3	T	-	-	-	HD
<i>Smilacina purpurea</i> Wadle	Liliaceae	C, D, E	1700-3300	3, 7, 12	H	-	-	-	HD
<i>Osbeckia stellata</i> Buch.-Ham. ex D. Don	Melastomaceae	A, B, C, D, E	1300-2000	1, 2, 7	Sh	-	-	-	HD
<i>Toona serrata</i> (Royle) M. Roem.	Meliaceae	A, B, C, D, E	1600-2600	1, 2, 4, 12	T	-	-	-	OE, HD
<i>Melia azedarach</i> L.	Meliaceae	A, B	1300-1600	1, 2, 8, 12	T	-	-	-	OE, HD
<i>Cissampelos pareira</i> L.	Menispermaceae	A, B, E	1300-2100	2, 3, 4, 12	H	-	-	-	HD
<i>Osmunda claytoniana</i> L.	Osmundaceae	A, E	2000-3000	1, 2, 7	Fn	-	-	-	HD
<i>Peperomia tetraphylla</i> (Forst. f.) H. & Arn.	Piperaceae	A, B, D, E	2000-2400	1, 5	H	-	-	-	HD
<i>Cymbopogon martinii</i> (Roxb.) Wats.	Poaceae	A, B	1500-2200	1, 3, 4	H	-	-	-	HD
<i>Bistorta affinis</i> (D. Don) Greene*	Polygonaceae	C, E	3000-3400	1, 7, 12	H	-	-	-	HD
<i>Polygonum vacciniifolium</i> Wall. ex Meissn.*	Polygonaceae	E	3000-3400	1, 7	Sh	-	-	-	HD
<i>Pteris biaurita</i> L.	Pteridaceae	A, B, C, D, E	1300-2000	1, 3, 4, 5, 10	Fn	-	-	-	HD
<i>Prunus cerasoides</i> D. Don	Rosaceae	E	1300-2200	1, 12	T	-	-	-	HD
<i>Cotoneaster bacillaris</i> Wall. ex Lindl.*	Rosaceae	A, B, C, D, E	2000-3000	1, 2, 7	Sh	-	-	-	HD
<i>Pedicularis bicornuta</i> Klotz.*	Scrophulariaceae	D, E	2000-3400	7, 11	H	-	-	-	HD
<i>Viola serpens</i> Wall. ex Roxb.	Violaceae	A, B, C, D, E	1600-2800	1, 2, 3, 4, 5, 12	H	-	-	-	OE, HD
<i>V. biflora</i> L.	Violaceae	A, B, C, D, E	2000-3400	1, 5, 6, 7, 11	H	-	-	-	OE, HD
<i>V. canescens</i> Wall. ex Roxb.*	Violaceae	A, B, C, D, E	1500-3400	1, 2, 3, 4, 7, 12	H	-	-	-	OE, HD

Abbreviations used: A=Sainj HEP; B=Sainj area of Parbati HEP Stage II; C=Gadsa area of Parbati HEP Stage II; D=Barshaini area of Parbati HEP Stage II; E=Malana II HEP; **=Endemic; *=Near endemic; AR=Altitudinal Range; LF=Life Form; HP=Himachal Pradesh; GB=Global; RD=Red Data Book; T=Tree; Sh=Shrub; H=Herb; Fn=Fern; R=Rare; CR=Critically Endangered; EN=Endangered; VU=Vulnerable; I=Forest;

2=Riverine/Watercourse; 3=Shady Moist; 4=Dry; 5=Bouldary; 6=Rocky; 7=Degraded; 8=Waste Place/Road Side; 10=Land slide; 11=Near crop field/orchards; and 12=Dam submergence area; OE=Over Exploitation; and HD=Habitat Degradation.

The Himalayas covers eight countries (i.e., Afghanistan, Bangladesh, Bhutan, China, Myanmar, Nepal, Pakistan, and India) and are supposed to be a rich storehouse of valuable threatened plant species. The Himalayas cover 18% of the Indian subcontinent, account for more than 50% of India's forest, and contain 40% of India's endemic species¹⁷. The area harbors about 8000 species of angiosperms of which 1748 are used for medicinal purposes¹⁸. In the present scenario, biodiversity crisis is being experienced throughout the globe. Therefore, appropriate conservation actions need to be set up in the most efficient way possible to optimally use limited resources. Unfortunately, none of the available methods of conservation priority setting are widely accepted as their data requirements are too stringent, scientifically unsound, or are too complex for the usage by decision makers¹⁹. In most of the studies, identification of threatened species has been carried out using qualitative attributes/observations, only. However, assessment of the status of species using standard format including qualitative as well as quantitative attributes has been suggested by few workers²⁰. Knowing the importance of floristic diversity for the human being, threat categorization at local, regional and global levels are essentially required. Threat categorization at local level would help in developing adequate management plans. In view of this, threat categorization of floristic diversity at local level along an altitudinal and horizontal gradients has been initiated in the IHR. So that based on grass root level information adequate management plan could be developed for the entire IHR and globe.

Habitat specificity, population size, distribution range and use pattern play an important role in identification of status of the species. In the present study, threat assessment of floristic diversity for a particular region has been carried out. On the basis of Threat Categorization Score (TCS), species have been categorized. The more TCS indicates the need for a greater level of attention to local strategies for conservation and management. Categorization of 16 species as Critically Endangered, 28 species as Endangered; 85 species as Vulnerable and 60 species as Near Threatened indicates the high degree of anthropogenic pressure. Occurrence of 21 species in one site only and 18 species in two sites indicated the early extinction of these species if the over exploitation and habitat degradation continue to operate. Similarly, occurrence of 06 species only in one habitat and 47 species in two habitats indicated their habitat restriction in the area. Such

species have less chances of proliferation than the species with wide range of habitats²⁰. Amongst habitats, 142 species were reported from the forest, 99 species in riverine/watercourse, 97 species in shady moist, 84 species degraded, 55 species in dam submergence, 54 species in bouldary, 40 species in dry, 16 species in rocky, 12 species, each in waste place/roadside and near crop field/orchards and 10 species in landslide areas support maximum number of threatened species, hence merit conservation attention. Altitudinal zone, 1300-1800m and 1801-2800m showed the richness of threatened species.

CONCLUSION: Land use, climate change, nitrogen deposition, biotic exchange and atmospheric carbon dioxide have been the major cause of changes in biodiversity. This may be due to heavy biotic pressure on this zone leading to habitat degradation and ultimately to extinction of the species. The over-exploitation, habitat degradation and changing environmental conditions may lead to the extinction within a few years. Hence, regular monitoring of population and habitats, development of conventional protocol, establishment of species in-situ conditions and associated habitats and replication of this approach in other parts of Indian Himalayan Region have been recommended. So that the gene pool of this unique group of plants could be maintained posterity. Therefore, to develop an appropriate strategy for the conservation and management of all these threatened species and their habitats, population assessment and habitat monitoring using standard ecological methods are urgently required.

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