Floristic Diversity of the Himalaya in Relation to Climate Change: Status, Values and Conservation

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Abstract

The Himalayan region is very well known for the unique ecosystems. The Indian Himalayan Region (IHR) forms the major part of the Himalayan region. The vegetation along an altitudinal gradient comprises of tropical, sub-tropical, temperate, sub-alpine and alpine types and supports a great variety of forests with unique species that vary from east to west and from low to high altitudes. The present study is based on the review of literature and surveys in some parts of the IHR. A total of 10,503 species (10,452 species of Angiosperms and 51 species of Gymnosperms) are reported from the Himalayan region. The Indian Himalayan Region (IHR) represents 18,940 species of plants representing Angiosperms, Gymnosperms, Pteridophytes, Bryophytes, Lichens, and Fungi. A total of 6745 species of Angiosperms (604 trees, 1049 shrubs & 5092 herbs) belonging to 225 families, 1768 genera are recorded from the Trans, North-West and West Himalaya based on surveys and review of literature. Diversity of the orchids, medicinal plants, wild edibles, other economically important plants, factors affecting floristic diversity, impact of climate change and conservation initiatives have been discussed.

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Appropriate strategy is suggested for the conservation and management of floristic diversity.

Keywords: Indian Himalayan region, floristic diversity, orchids, medicinal and wild edible, factors, climate change, conservation initiatives.

Introduction

The Himalaya literally meaning "Abode of Snow" is one of the youngest mountain range in the world which lies in South Asia and separates the Indo-Gangetic Plain from the Tibetan Plateau. This great mountain system extends over nearly 3000 Km, almost from the borders of Afghanistan in the West to the North of Burma in the East, approximately between 27°–36° N Latitudes and 72°–91° E Longitudes, connecting the mountains of Near East and Central Asia with those of East Asia (Atkinson, 1982). The Nanga Parbat acting as western anchor of the Himalaya lies just south of the northernmost bend of the Indus River and Namcha Barwa as eastern anchor situated just west of the great bend of the Yarlung Tsangpo River. The Himalaya is bordered on the North by the Tibetan Plateau, on the South by the Indo-Gangetic Plain, on the Northwest by the Karakoram and Hindu Kush ranges, and on the East by the Indian states of Assam and Arunachal Pradesh. The Himalaya spans five countries namely, India, Nepal, Bhutan, China (Tibet), and Pakistan, with the first three countries having sovereignty over most of the range. The Himalayan ranges can be grouped into four parallel longitudinal mountain belts of varying width designated, from south to north, as the Outer, or Sub- Himalaya or Siwalik Range; the Lesser, or Lower Himalaya; the Great Himalaya Range (Great Himalaya); and the Tethys or Trans-Himalaya. Farther north lies the Trans-Himalaya in Tibet proper and from west to east the Himalaya is divided broadly into three mountainous regions i.e., western, central, and eastern (Encyclopedia Britannica, 2012; www.britannica.com). The Himalayan mountain range is gifted with a wide range of flora and fauna by nature as it straddles a transition zone between the Palearctic and Indo Malayan realms, with species from both the realms contributing to the biodiversity of this recently designated hotspot (Myers et al., 2000). The enormous diversity of ecosystems and immense biological diversity of the Himalaya is attributed to its wide range of altitude, rainfall, climate, geological conditions, river systems and topography. The Himalaya is a rich storehouse of endemic, medicinal, economically important, multipurpose, rare and endangered plants and animals.

Study Area

The Indian Himalayan Region (IHR) lies between 27°–38° N Latitudes and 72°–89° E Longitudes and covers approximately an area of 4,19,873 Km^2 (about 18% of India) with more than 2,800 km long and 220 to 300 km wide. The altitude ranges from 200–>8000 m amsl (Anonymous 1992). It includes the parts of Trans, North-west, West, Central and East Himalaya, and ranges from Arunachal Pradesh to Jammu and Kashmir and Ladakh Union Territories and rising upto an altitude of > 8000 m amsl (Figure 1). It supports three bio-geographic zones (i.e., Trans Himalaya, The Himalaya and North-East India) and 8 bio-geographic provinces (i.e., Ladakh Mountains, Tibetan Plateau, North west, West, Central & East Himalaya, Brahmaputra valley and North East Hills) (Rodger and Panwar, 1988). The unique physiography, climatic conditions and soil characteristics of the area have resulted in a variety of habitats and a significant biological and cultural diversity. The vegetation along an altitudinal gradient comprises of tropical, sub-tropical, temperate, sub-alpine and alpine types and supports a great variety of forests with unique species that vary from east to west and from low to high altitudes. These forests have traditionally played a key role in safeguarding the ecology

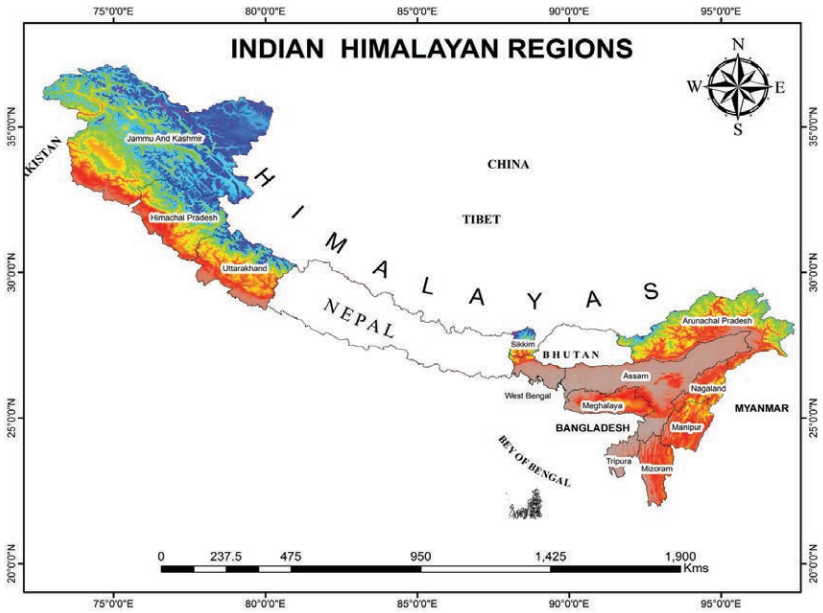

Figure 1 Location map of the Indian Himalayan Region.

and environment of the sub-continent (Samant et al., 2002; Joshi and Samant, 2004).The Indian Himalayan Region (IHR) is very well known for its representative, natural, unique and socio-economically important floristic diversity (Samant et al., 1998a). It is designated as one of the Biodiversity Hot Spots (Chatterjee, 1938; Mittermeier et al., 2004). The dependence of humans and livestock on this rich floristic diversity is well known phenomenon since time immemorial (Samant and Dhar, 1997; Samant et al., 1998b). The richness of the biological diversity is due to its unique climatic conditions, topography and diverse habitats (Samant et al., 1998b). The entire region is endowed with a wide range of physiography, climate, soil and biological wealth. It has wide altitudinal range (200–>8000 m, amsl) with rich diversity of habitats providing a range of microclimate and niches not only for plants, but also for animals (Samant et al., 2002; Joshi and Samant, 2004).

The cultural groups of the IHR comprises of Gaddis, Gujjars, Swangla, Lahulas and Pangwalas (Trans, North West Himalaya); Bhotias, Rajees, Tharus, Buxas and Jaunsarrees (West Himalaya); Bhutias and Lepchas (Central Himalaya); and Chakma and Nagas (East Himalaya). The rich plant diversity of the IHR has been utilized by the natives in various forms such as medicine, food (edible), fuel, fodder, making agricultural tools, house building, small scale enterprises (i.e., basket, mat, hat, kilta, *etc*.), and religious ceremonies (Samant and Dhar, 1997; Samant, 2015).

Floristic Diversity

A total of 10,452 species of Angiosperms belonging to 2302 genera and 232 families and 51 species of Gymnosperms belonging to 8 families, 20 genera are reported from the Indian Himalayan Region, Nepal and Bhutan (Rana and Rawat, 2017). Of the reported species of vascular plants in the Himalayan region, approximately 3160 species are endemic (Chatterjee, 1938; Mittermeier et al., 2004).

The Indian Himalayan Region (IHR) represents 18,940 species of plants, of which 8,500 species (40% endemics) are represented by Angiosperms; 44 species (15.91% endemics) by Gymnosperms, 600 species (25% endemics) of Pteridophytes; 1737 species (32.53% endemics) of Bryophytes; 1,159 species (11.22% endemics) of Lichens; and 6,900 species (27.39% endemics) of Fungi (Singh and Hajra, 1996).

A total of 6745 species of Angiosperms belonging to 225 families, 1768 genera have been recorded from the Trans, North West and West Himalaya. Of the total species, 604 species were trees, 1049 shrubs

and 5092 herbs (Samant, 2015). From Arunachal Pradesh, 3984 species of Angiosperms and 21 species of Gymnosperms; Assam, 3010 species of Angiosperms and 07 species of Gymnosperms; Manipur, 2376 species of Angiosperms and 05 species of Gymnosperms; Meghalaya, 1886 species of Angiosperms and 06 species of Gymnosperms; Mizoram, 2141 species of Angiosperms and 06 species of Gymnosperms; Nagaland, 2431 species of Angiosperms and 09 species of Gymnosperms; Tripura, 1463 species of Angiosperms and 13 species of Gymnosperms; and Sikkim, 4458 species of Angiosperms (Naithani, 2020).

The group Gymnosperms is represented in the IHR is Cupressaceae, Cycadaceae, Ephedraceae, Ginkgoaceae, Pinaceae, Podocarpaceae, Taxaceae and Taxodiaceae (Rana and Rawat, 2017).

The Angiosperms is a largest group of plants. Among the Angiosperms families, Asteraceae, Poaceae, Fabaceae, Orchidaceae, Brassicaceae, Lamiaceae, Euphorbiaceae, Scrophulariaceae, Rubiaceae, Liliaceae, Apiaceae, Polygonaceae, Acanthaceae, Rosaceae, etc. are the species rich and contribute maximum number of species. Some of the families are monotypic, represented by only one species. The notable monotypic families were Actinidiacaceae, Adoxaceae, Allocasurinaceae, Bieberstiniaceae, Calycanthaceae, Cannaceae, Cariacaceae, Ceratophyllaceae, Circaesteraceae, Clusiaceae, Coriariaceae, Daphniphyllaceae, Datiscaceae, Dipterocarpaceae, Droseraceae, Hippuridaceae, Icacinaceae, Iteaceae, Lardizabalaceae, Leeaceae, Marantaceae, Martyniaceae, Melianthaceae, Moringaceae, Myricaceae, Ochnaceae, Paeoniaceae, Platanaceae, Plumbaginaceae, Podophyllaceae, Podostemaceae, Proteaceae, Punicaceae, Rhizophoraceae, Saurauiaceae, Sonneratiaceae, Saururaceae, Sphenocleaceae, Stylidiaceae, Toricelliaceae, Trillidiaceae, Tropaeolaceae, Zannichelliaceae, etc. Among the genera, *Carex, Taraxcum*, *Potentilla*, *Astragalus*, *Saxifraga*, *Cotoneaster, Artemisia*, *Cyperus, Polygonum, Corydalis, Berberis, Euphorbia, Silene, Poa, Primula, Pedicularis, Nepeta, Impatiens, Ranunculus, Persicaria, Veronica, Allium, Rubus, Ficus,* etc. were found to be dominant in Trans, North West and West Himalaya (Samant, 2015).

Conservation and Socio-economic Values

Diversity of Orchids

Among the Angiosperm families, family Orchidaceae is very well represented across the Indian Himalayan Region. The extensive and intensive

review of literature revealed that the North East India (i.e., Sikkim – 138 genera, 523 species; Arunachal Pradesh – 141 genera, 568 species; Assam – 59 genera, 145 species; Meghalaya – 107 genera, 361 species; Nagaland – 98 genera, 348 species; Mizoram – 81 genera, 237 species; Tripura – 27 genera, 35 species; & Manipur – 87 genera, 296 species) alone supports 165 genera and 900 species. Out of these, 563 species were epiphytes, 298 species terrestrial, 39 species mycotrophs, 108 species threatened and 131 species are endemic (Naithani, 2020). The surveys and reviews of literature of the orchids of Trans, North-Western and Western Himalaya, Central Himalaya (Sikkim) and North-Eastern Himalaya revealed the inventory of 960 species of orchids belonging to 158 genera. The Genera, *Bulbophyllum* (86 spp.), *Dendrobium* (82 spp.), *Eria* (45 spp.), *Liparis* and *Oberonia* (34 spp., each), *Habenaria* (30 spp.), *Cymbidium* (27 spp.), *Peristylus* (25 spp.) and *Calanthe* (23 spp.) were the species rich and contributed maximum number of species. Sixty percent species were native to the Himalayan region and 4.48% species were native to the Himalayan region and neighbouring Countries, together. Thirty one percent species were endemic and 16.46% species were near endemic for the Indian Himalayan Region. The Trans, North-Western and Western Himalaya support 244 species of orchids belonging to 5 sub-families and 72 genera (Pangtey et al., 1991; Samant, 2015). Among the sub-families, Epidendroideae represented 19 genera and 91 species, Orchidoideae represented 16 genera and 58 species, Vandoideae represented 21 genera and 50 species, Neottioideae represented 15 genera and 42 species, and Cypripedioideae represented one genus and 3 species. Among the genera, *Habenaria* represented (17 spp.), *Denbrobium* (15 spp.), *Bulbophyllum* (11 spp.), *Liparis, Oberonia* and *Peristylus* (10 spp., each), Eria (9 spp.), *Cymbidium, Herminium* and *Calanthe* (8 spp., each), *Malaxis* (7 spp.) and *Vanda* and *Coelogyne* (5 spp., each) represented the maximum number of species, respectively. Of the total species of Trans, North-Western and Western Himalaya, 168 species were native, 19 3ndemic and 63 near endemic. From Trans and North-Western Himalaya (Himachal Pradesh and Jammu & Kashmir and Ladakh Union Territory), 76 species of orchids belonging to 37 genera were recorded based on the surveys and review of literature. Himachal Pradesh represented 57 species and Jammu & Kashmir UT including Ladakh UT 50 species; 37 species were common in these states. Of the recorded species of orchids, 71 species were terrestrial and 5 species epiphytic. *Habenaria* (13 spp.), *Herminium* (5spp.), *Epipactis* (4spp.), and *Calanthe, Goodyera, Liparis, Malaxis, Peristylus, Neottia* and *Oreorchis* (3 spp., each) were the species rich genera. In stocktickerIHR, maximum species of the Orchids were distributed

in the sub-tropical zone (<1800 m) and minimum species in the alpine zone. Forty-one species have been recorded in the Red Data Book of Indian Plants. Some of the species have medicinal and horticultural values. Apart from the economic importance of orchids for their ornamental values, many orchids are also used in traditional system of medicine as a remedy of number of ailments and as food. They are rich in alkaloids, flavonoids, glycosides, carbohydrates and other phytochemical contents. The native communities of the stocktickerIHR use tubers of *Habenaria commelinifolia* (Roxb.) Wall. ex Lindl. for fever, nose bleeding, snake bite and wounds; *Malaxis mackinnonii* (Duthiei) Ames for sores in neck; *Eulophia dabia* (D. Don) Hochr. as blood purifier, sex diseases, tonic and edible; *Eulophia herbacea* Lindl. as tonic; *Dactylorhiza hatagirea* (Don) Soo for bone fracture, as an astringent, expectorant, tonic and healing the cuts and wounds; *Gymnadenia orchidis* for gastric, gonadic and urinary disorders; pseudobulbs of *Pholidota imbricata* Lindl. for abdominal pain, pain in navel, rheumatism, body pain and worms; *Coelogyne stricta* (Don) Schltr. for fever and headache; leaves of *Vanda testacea* (Lindl.) Reichb. f. for cuts and wounds, *Dendrobium moschatum* (Buch.-Ham.) Sw. for earache; whole plant of *Cymbidium longifolium* D. Don for the treatment of nervous disorders; and *Vanda tessellata* (Reichb.f.) Hk. ex G. Don for abscesses, antifertility, bone fracture, dyspepsia, earache, eye diseases, night blindness, rheumatism and sores. Similarly, there are other species of orchids, which could be used for the treatment of various ailments. Their potential as medicine has yet to be identified. Parts of the orchids have been also used as food. For example, roots/tubers of the species of *Eulophia, Gastrodia, Habenaria, Dactylorhiza, Pholidota* and *Spiranthes* are edible. These parts are mostly eaten raw, roasted and boiled. The orchid diversity of stocktickerIHR is under tremendous pressure due to anthropogenic activities (i.e., construction of roads, hydro-electric projects, expansion of agriculture land, degradation of forests, biological invasion, over exploitation of forest resources including orchids, grazing, etc.) and climate change (i.e., increase in maximum and minimum temperature, decrease in rain fall and humidity, etc.). Majority of the orchid species are moisture loving and continued anthropogenic activities and climate change may lead rapid depletion of populations of the orchid species, even may lead to extinction. Therefore, studies on habitat ecology of the orchids, assessment of populations, Ecological Niche Modelling of the native, endemic and threatened species, identification of host range of epiphytes, identification of Pressure Use Index (PUI) and Sensitivity Index (SI) of host plants, prioritization of economically important orchids, mass multiplication using conventional (vegetative and seed) and in

vitro methods, notification of orchid rich areas as Orchid Conservation Areas (OCAs), and awareness programs for the inhabitants and Forest Departments and their involvement in the conservation and management of orchids are suggested.

Medicinal Plants

A total of 1,748 species belonging to 915 genera and 223 families are reported from the IHR. The representation of taxonomic groups, families, genera, species, herbs, shrubs, trees and ferns are presented in Table 1. The families, Asteraceae (129 spp.), Fabaceae (107 spp.), Lamiaceae (63 spp.), Rubiaceae (55 spp.), Euphorbiaceae (51 spp.), Ranunculaceae (48 spp.), Rosaceae (41 spp.), Poaceae (40 spp.), Orchidaceae (37 spp.), Polygonaceae (32 spp.) and Gentianaceae (27 spp.), respectively represented the maximum medicinal plants. Among the genera, *Polygonum* (19 spp.), *Euphorbia* (16 spp.), *Piper* (16 spp.), *Ficus* (13 spp.), *Aconitum* and *Swertia* (12 spp., each), *Artemisia* (11 spp.), *Solanum, Berberis, Desmodium* and *Allium* (10 spp., each), *Saussurea* (9 spp.), respectively are medicinal plant rich (Samant et al., 1998).

Of the total medicinal plants, 25.8% species are native to the Himalaya region, 5.66% species native to the Himalayan region and neighbouring biogeographic domains together, 3.55% species endemic and 11.9% species near endemic to the IHR.

The altitudinal distribution of the medicinal plants is presented in Figure 1. Maximum species are distributed in the zone upto 1,800, and minimum are distributed in >3,800 m zone. Across the biogeographic provinces, maximum medicinal plants are found in Central Himalaya (i.e., Sikkim & Darjeeling Hills), followed by Western Himalaya (Uttarakhand), Trans and

Table 1 Diversity of Medicinal and Aromatic Plants (MAPs)

Taxonomic Group	Families	Genera	Species	Herbs	Shrubs	Trees	Ferns
Angiosperms	191	878	1685	1020	335	330	–
Gymnosperms	4	6	12	–	3	9	–
Pteridophytes	28	31	51	–	–	–	51
Total	**223**	**915**	**1748**	**1020**	**338**	**339**	**51**
Native: 309	**E: 26; NE: 126**		**Threatened: 165: Agrotechniques: 30**				

Source: Samant, Dhar & Palni, 1998.

North Western Himalaya (Himachal Pradesh and Jammu & Kashmir and Ladakh Union Territories).

The notable medicinal plants of the IHR are *Aegle marmelos, Azadirachta indica, Berberis asiatica, B. aristata, Boerhaavia diffusa, Justicia adhatoda, Gloriosa superba, Syzygium cumini, Withania somnifera, Costud speciosa, Coleus forskohlii, Didymocarpus pedicellata, Rauwolfia serpentina, Asparagus racemosus, Oroxylum indicum, Tinospora cordifolia, Terminalia arjuna, chebula, T. bellirica, Glycyrrhiza glabra, Mucuna pruriens, M. bracteata, Pholidota articulate, Swertia angustifolia, S. chirayita, S. cordata, Hypericum perforatum, Heracleum lanatum, Cinnamomum tamala, Viola canescens, Bergenia ligulata, Hedychium spicatum, Phyllanthus emblica, Plantago major, Acorus calamus, Paris polyphylla, Taxus wallichiana, Thalictrum foliolossum, valeriana wallichii, Adiantum venustum, Angelica glauca, A. nubigena, Lilium polyphyllum, Trillium govanianum, Corydalis govaniana, Inula racemosa, Bunium persicum, Saussurea costus, S. obovata, Arnebia benthamii, A. euchroma, Picrorhiza kurroa, Dactylorhiza hatagirea, Aconitum heterophyllum, Sinopodophyllum hexandrum, Rheum australe, Nardostachys jatamansi, Panax pseudogeinseng, Fritillaria roylei, Rhododendron anthopogon, Ephedra gerardiana, Hippophae rhamnoides ssp. turkestanica, Coptis teeta,* etc. (Samant et al., 1998).

Seventeen medicinal plants i.e., *Saussurea costus* (Endangered), *Aconitum deinorrhizum, A. falconeri* var. *latilobum, A. ferox, Allium stracheyi, Berberis affinis, Coptis teeta, Dioscorea deltoidea, Inula racemosa, Nardostachys jatamansi, Panax pseudoginseng* and *Picrorhiza kurroa* (All Vulnerable), *Berberis kashmiriana, Codonopsis affinis,* and *Saussurea bracteata* (All Rare) and *Angelica nubigena* and *Pittosporum eriocarpum* (Both Indeterminate) are recorded in the Red Data Book of Indian Plants (Nayar and Sashtry, 1987, 1988, 1990; Samant et al., 1998a). One hundred twenty species (120 spp.) are assessed for different threat categories i.e., Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, and Data Deficient by organizing Conservation Assessment and Management Plan (CAMP) Workshops and involving the Subject Experts of the IHR (Ved et al., 2003, 2005). Agrotechniques of >30 high value commercially viable medicinal plants are known which are being utilized for the mass multiplication and cultivation of medicinal plants by the progressive farmers in the IHR (Samant et al., 2008). Recent study carried out on the Assessment Valuation and Conservation Prioritization of Floristic Diversity in the Trans, North Western and Western Himalaya reported 3174 species of medicinal plants based on the surveys and thorough literature review (Samant, 2015). Further

investigations are required in other parts of the IHR to develop comprehensive data base and strategy for the conservation of medicinal plants.

Wild Edible Plants

From the IHR, 675 wild edible plants representing 384 genera and 149 families are known. Of these, 285 species are herbs, 172 species shrubs, 197 species trees, 12 species Pteridophytes, 07 species Fungi and 02 species Lichens. The families, Rosaceae (45), Polygonaceae (30), Moraceae (26), Asteraceae (20), Fabaceae (20), Euphorbiaceae (15), Anacardiaceae (13), Rubiaceae (13), Apiaceae (13), Urticaceae (14), Lamiaceae (12), Alliaceae (12), Rutaceae (12), Poaceae (13), Berberidaceae (11), Caprifoliaceae (10), and Vitaceae (10), respectively support the highest number of edible plants. Among the genera, *Rubus* (20), *Polygonum* (18), *Ficus* (15), *Allium* (12), *Dioscorea* (9), *Berberis* (8), *Prunus* (7), *Viburnum* (7), *Ribes* (6), *Piper* (6), *Grewia* (5), *Rhus* (5), and *Chenopodium* (5) are the genera with high species richness. Representation of the taxonomic groups, families, genera and species of wild edible plants in the IHR is presented in Figure 2. Various part(s) i.e., whole plant, leaf, seed, fruit, tender shoot, root, tuber, rhizome, thallus, fronds fruiting body and miscellaneous parts of the wild edible plants are either consumed raw, roasted, boiled, fried, cooked or in the form of oil, spice, seasoning material, jams, jelly, pickle, etc. (Figure 3).

The maximum wild edible species are distributed in tropical and sub-tropical zone (i.e., upto 1800 m). The diversity of wild edible species decreases with the increasing altitude i.e., tropical & sub-tropical to temperate, sub-alpine and alpine zones. The distribution of wild edible species across the biogeographic provinces in the IHR is presented in Figure 4. Of

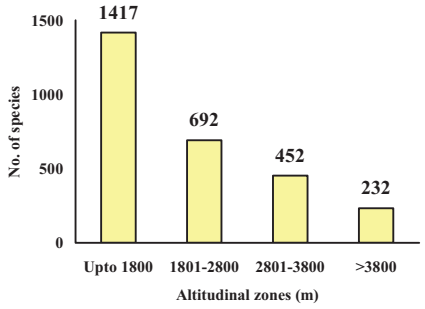

Figure 2 Altitudinal distribution of Medicinal Plants in IHR.

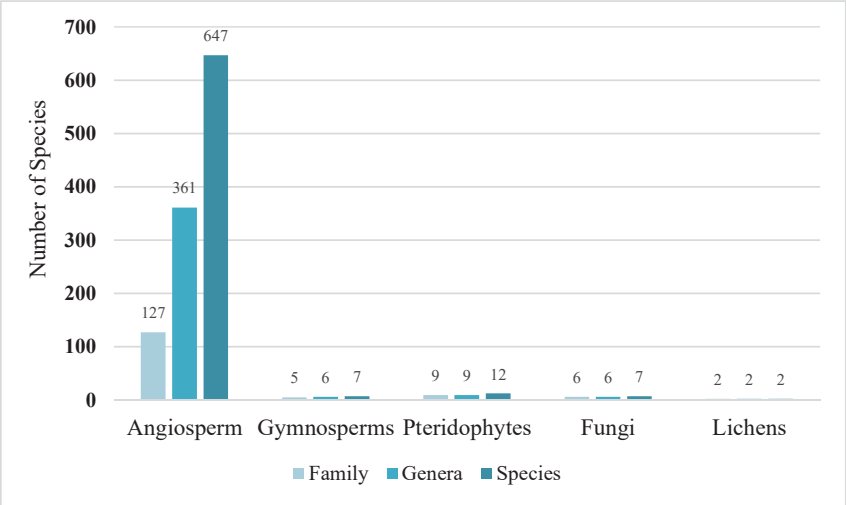

Figure 3 Representation of taxonomic groups, families, genera and species of wild edible plants in the IHR.

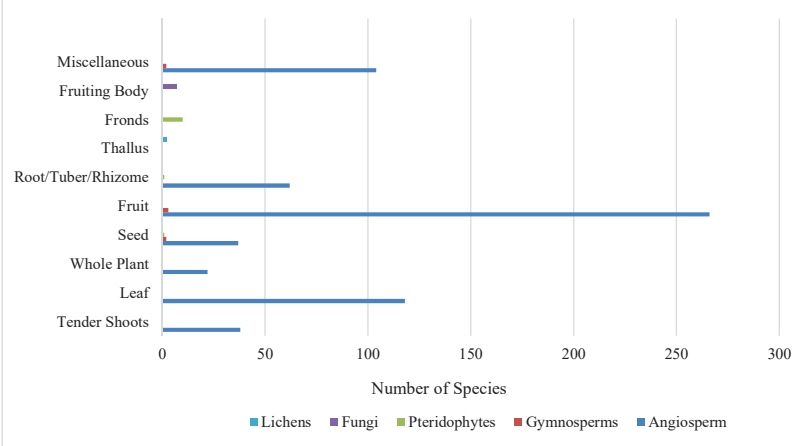

Figure 4 Part (s) of wild edible plants used by the inhabitants in the IHR.

the 675 species of wild edibles, 286 species are native, 39 endemic and 93 near endemic. The remaining species are non- natives, represents different biogeographic provinces of the globe (Samant and Dhar, 1997).

Some of the notable edible plants are *Eremurus himalaicus*, *Prunus ceracifera*, *Hippophae rhamnoides* ssp. *turkestanica*, *S. salicifolia*, *Saurauia*

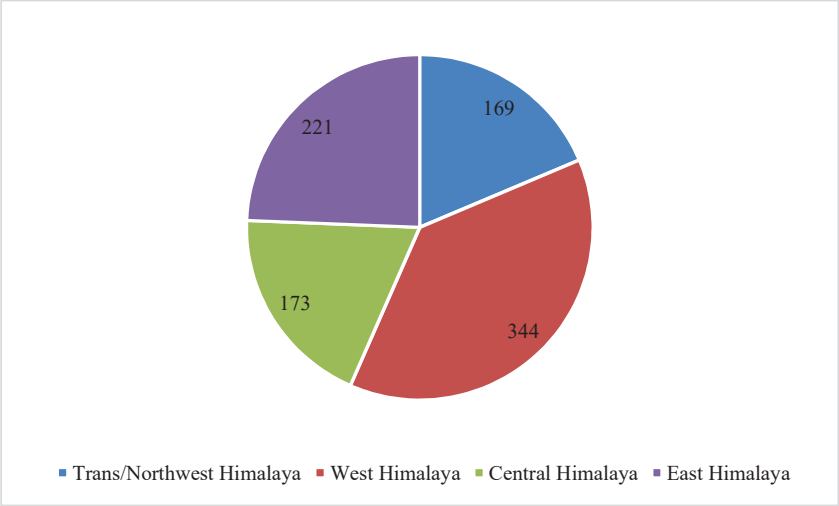

Figure 5 Distribution of wild edibles across the biogeographic provinces in the IHR.

nepaulensis, *S. panduana*, *Castanopsis* spp., *Corylus jacquemontii*, *Pinus gerardiana*, *Syzygium cumini*, *S. venosum*, *Aegle marmelos*, *Coriaria nepalensis, Myrica esculenta, Pinus roxburghii, Elaeagnus conferta, Cornus capitata, Fagopyrum debotrys, Diplagium esculentum*, *Allium* spp., *Berberis* spp., *Rubus* spp., *Rosa* spp., *Ribes* spp., *Rheum* spp., *Maytenus rufa, Diploknema butyracea, Pyrus pashia, P. lanata, Crataegus songarica, Morchella esculenta, Mahonia nepaulensis*, *M. sikkimensis*, *Musa sanguine*, *Schisandra grandiflora*, *Malus sikkimensis, Ziziphus mauritiana*, *Phoenix humile, Ficus* spp., etc.

Recent study carried out on the Assessment, Valuation and Conservation Prioritization of Floristic Diversity in the Trans, North-Western and Western Himalaya reported 925 species of wild edible plants based on the surveys and thorough literature review (Samant, 2015; Figure 6). Such comprehensive study on Assessment, Valuation and Conservation Prioritization of Floristic Diversity in the North-East India is also required for developing the data base and strategy for the conservation of wild edible plants.

Other Economically Important Plants

A total of 4,035 species belonging to 1461 genera and 207 families of economically important plants are reported from the Trans, North-Western and

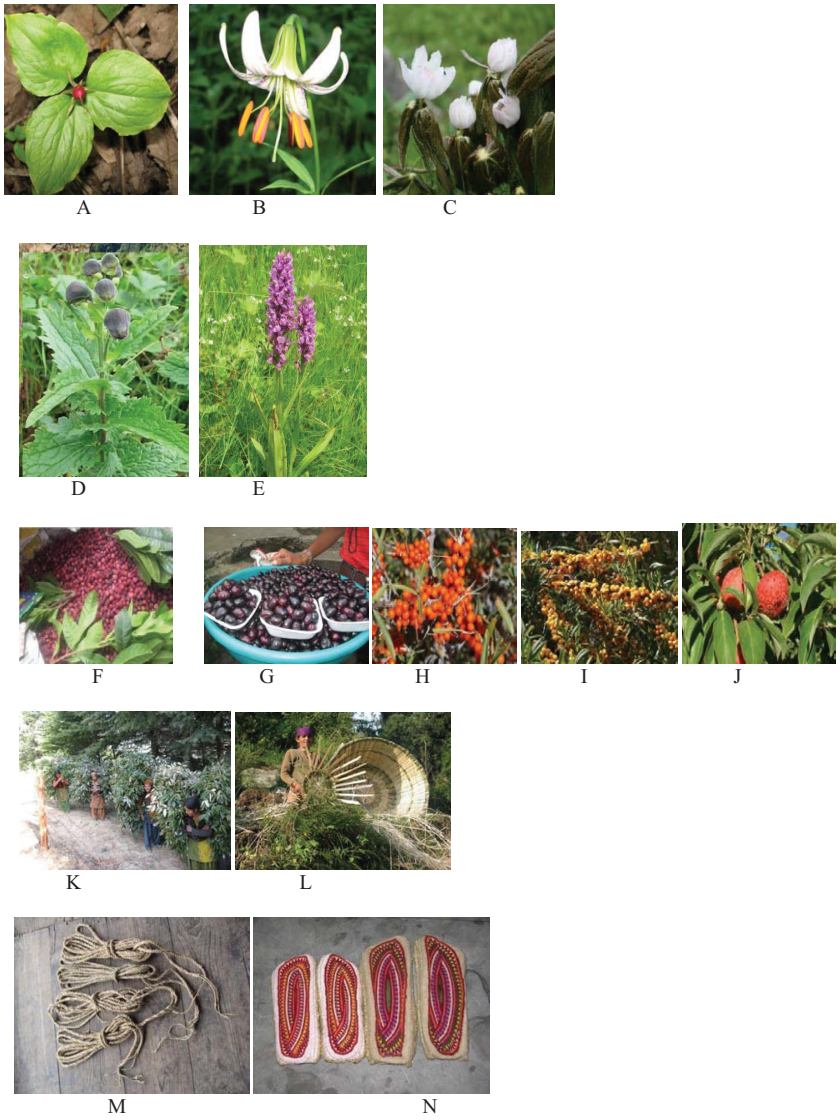

Figure 6 Utilization of floristic diversity in IHR; Medicinal plants (A–E); A = *Trillium govanianum*, B = *Lilium polyphyllum*, C = *Sinopodophyllum hexandrum*, D = *Aconitum heterophyllum*, and E = *Dactylorhiza hatagirea*; Wild edibles (F–J); F = *Myrica esculenta*; G = *Syzygium venosum*, H = *Hippophae rhamnoides* ssp. *turkestanica*, I = *Hippophae salicifolia*, and J = *Cornus capitata*; K = Fodder collection of *Quercus oblongata*; L = Entrepreneurship from *Drepanostachyum falcatum*: and M–N = Entrepreneurship from *Cannabis sativa*.

Western Himalaya. Amongst the reported economically important species, in addition to the medicinal and wild edible plants, 683 species are used as fodder, 262 species as fuel, 159 species as timber/house building, 148 species as religious, 43 species as fiber, 50 species for making agricultural tools, 23 species as dye and 201 species as ornamental (Samant, 2015).

Factors Affecting Floristic Diversity

Floristic diversity of the IHR is facing tremendous pressure due to various anthropogenic activities. The over exploitation and habitat degradation of the species due urbanization, forest degradation, construction of roads, industrialization, construction of Hydro-electric projects, forest fire and biomass burning, tourism beyond carrying capacity, overgrazing, unmanaged solid waste dumping, biological invasion, conversion of forest land into agriculture land, etc. have caused the rapid population depletion of the populations of many ecologically and ecologically important species, deduction in ecosystem services, ecosystem imbalance and environmental changes. The factors are also leading to the climate change in the region. The population explosion is also a major problem leading to increased demand of ecologically and economically important floristic components, ultimately leading their rapid population depletion. If the above factors continue to operate, the species which are placed under Critically Endangered, Endangered and Vulnerable categories of the International Union for Conservation of Nature (IUCN), may become extinct, even other species falling under Near Threatened, Least Concern and Indeterminate categories may also fall Critically Endangered, Endangered and Vulnerable categories.

Impact of Climate Change

Various anthropogenic activities have led ecosystem imbalance, deduction in ecosystem services and change in the environmental conditions including climate change. The meteorological data of the region indicate that there is increase in the maximum and minimum temperatures and decrease in rain fall and snow fall. Such changes in the environmental conditions have caused shift in the flowering period and altitudinal shift of the species. Early flowering in *Rhododendron arboreum, R. campanulatum, Myrica esculenta, Reinwardia indica, Bombax ceiba, Jasminum* spp., Rosaceous species i.e., *Malus pumila* (Apple), *Pyrus* spp., *Prunus* spp., *Rubus* spp., *Rosa* spp., etc.

Figure 7 Impact of climate change; A–B = Early flowering in *Rhododendron campanulatum* (A) and *R. arboreum* (B); C–D = Altitudinal shift of *Juniperus polycarpos* in Lahaul valley; and E–G = Occurrence of tropical species, *Mangifera indica* (A), *Psidium guajava* (F), and *Withania somnifera* (G) in Kullu valley.

have been observed (Personal observations) (Figure 7). Such shift in the phenology of species is leading to the changes in biological cycle of the species, which is affecting the pollination of many cross pollinated species. Increase in the maximum and minimum temperatures and decrease in rain fall and snow fall is promoting the altitudinal shift of the pests and pathogens.

In Kullu Valley of the Himachal Pradesh, shift in Apple belt from Nagwai to Dove, Katrain (Approximately 35–40 km), introduction of Mango, Guajava, Papaya and Citrus fruits have been observed. Similarly, occurrence of wild species such as, *Withania somnifera* (Ashvagandha), *Sapium sebiferum*, *Dalbergia sissoo*, *Woodfordia fruticosa, Justicia adhatoda* (All tropical plants), etc.; and apple plantation and production in Lahaul and Spiti Valley, Pooh Block of Kinnaur district clearly shows the impact of climate change on the floristic diversity (Figure 7).

The upward (upto 2600 m) and downward (300 m shift) of the *Pinus roxburghii*, an opportunistic species also shows the changes in environmental conditions. Compositional changes particularly in seedlings and saplings of the sub–alpine forests namely, *Abies pindrow, Quercus semecarpifolia, Betula utilis*, etc. and altitudinal shift of *Juniperus polycarpos* (in Lahaul Valley), *Pinus gerardiana* (in Pooh Block of Kinnaur district and Pangi Valley), *Pinus wallichiana, Abies pindrow, Betula utilis, Populus ciliata, Rhododendron campanulatum,* etc. have been reported (Figure 7). This could be as a consequence of climate change (Devi and Samant, 2019, Lal and Samant, 2019, Singh and Samant, 2020). Similarly, occurrence of *Taxus wallichiana* in Lahaul valley in the form of saplings and seedlings revealed the recent arrival of this species in the Lahaul valley. This clearly shows that changing environmental conditions particularly climate change is leading to altitudinal shift of the species (Lal et al., 2020). In Lahaul valley, the occurrence of seedlings and saplings of *Juniperus polycarpos* in avalanche prone areas and beyond the altitudinal distribution of the species in the higher elevations is the clear-cut evidence of impact of climate change (Singh and Samant, 2020) (Figure 7). Also, occurrence of *Pinus wallichiana* in the altitudinal range of *Betula utilis* and *Rhododendron campanulatun* in Himachal Pradesh (Sangla Valley; Personal observation) and Nanda Devi Biosphere Reserve (Samant and Joshi, 2004) is the evidence of impact of climate change. Therefore, monitoring of floristic diversity in relation to climate change needs priority attention for understanding the dynamics of the species and planning for the conservation of floristic diversity.

Conservation Initiatives

The Government of India in consultation with State Governments have taken the initiatives for the *in-situ* (i.e., conservation of natural habits and ecosystems) and *ex-situ* (i.e., conservation of species outside the natural habitats) conservation of the biodiversity. Considering the richness of the biota, a Protected Area Network (PAN) has been established throughout the country and IHR, and most of the representative biodiversity rich area have been protected as Biosphere Reserves (BRs), National Parks (NPs) and Wildlife Sanctuaries (WS) to conserve the ecosystems, habitats and species, respectively (Rodgers and Panwar, 1988). At present, the IHR, represents 28 NPs, 99 WS, and 07 BRs covering a total geographical area of 51,899.239 km^2 excluding North East India (Mathur et al., 2000; Samant et al., 2002; Rana and Samant, 2009; Samant et al., 2012; Sharma and Samant, 2019).

A B C

Figure 8 Conservation of floristic diversity (A–C); A = *Aconitum heterophyllum*, B = *Withania somnifera*, and C = Arboretum at Mohal, Kullu.

The IHR has the pride of having World Heritage Sites in the North West, West Himalaya and the North East India. These are Nanda Devi Biosphere Reserve, Valley of Flowers, Great Himalayan National Park, Kanchendzonga Biosphere Reserve, Manas Biosphere Reserve and Kaziranga National Park. In addition to these, Sacred Groves, Ramsar Sites, Tiger Reserves, Reserve Forests, etc. are also identified for the in situ conservation of biodiversity including floristic diversity. For the ex-situ Conservation, Botanical Gardens, Arboreta, Nurseries, Herbal Gardens, Zoos, Parks, etc. have been developed by the State and Central Government organizations, Universities and others for the conservation of ecologically and economically important floristic diversity (Figure 8).

In the IHR, studies on the assessment, valuation and conservation prioritization of floristic diversity of the protected areas have been carried out by some workers (Dhar et al., 1997; Joshi and Samant, 2004, 2014; Rana and Samant, 2009, Singh and Samant, 2010, Sharma and Samant, 2019, Lal and Samant, 2019, Devi et al., 2019). However, most of the protected areas are under explored or unexplored. Some of the studies are restricted to flora, ecology, ethnobotany, etc. Therefore, an integrated study comprising floristic diversity, community diversity, regeneration pattern of the trees, resource utilization pattern, nativity and endemism of the species, threat categorization and conservation prioritization is essentially required for developing the appropriate strategy for conservation.

Conclusion

In the Indian Himalayan Region, the available studies on floristic diversity are fragmentary and do not provide comprehensive inventory of the regions/states. Based on the fragmentary information about the floristic

diversity, it is very difficult to develop an appropriate strategy and reach any concrete conclusion. Therefore, it is essential to prepare a comprehensive inventory of the floristic diversity following the authentic nomenclature. The comprehensive investigation of floristic diversity in Trans, North Western and Western Himalaya has provided the robust data base on floristic diversity, native, endemic, threatened and economically important species. Such comprehensive information would help in the management planning of floristic diversity of these regions (Samant, 2015). Such robust data base is also required for other parts of the Himalaya and country, so that proper strategy and management plans could be developed and implemented for the conservation of floristic diversity in particular and biodiversity in general. The past studies carried out in the IHR have revealed that the diversity of species, communities, economically important plants, and native, endemic and threatened plants along the topographical gradients i.e., habitats, aspects and altitude (Rana and Samant, 2009, Singh and Samant, 2010, Devi et al., 2019, Lal and Samant, 2019). The utilization pattern of economically important plants depends on the availability of the species along the altitudinal and across the horizontal gradients (Samant et al., 2007). There is a need to; (i) Assess, valuate, map and prioritize the floristic diversity including protected areas at gene, species and ecosystem levels in the changing anthropogenic and climate change scenarios and develop a user friendly electronic data base of floristic diversity; (ii) Harnessing the potential of NTFPs including medicinal plants, wild edibles, orchids and bamboos for sustainable livelihood and small scale enterprise development; (iii) Monitor the extraction trends of fuel and fodder resources by the inhabitants; (iv) Establish Long Term Ecological Monitoring Stations in areas sensitive to climate changes; (v) Develop packages of practices for the maintenance and optimal use of ecologically and economically important floristic diversity and improve the bio-resource based livelihood options for indigenous communities; and (vi) Promote in – situ and ex – situ conservation and awareness among the stakeholders; and (vii) Develop a strong network/coordination of the State and Central Government Departments, NGOs and other stakeholders for information sharing.

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Biography

S. S. Samant is Ph.D. and D.Sc. from Kumaun University, Nainital. He discovered new species, new hybrid, species new to India; new to Western Himalaya and Kumaun Himalaya; developed an integrated approach for floristic diversity assessment; State of art approaches for extraction trends of fuel and fodder resources; threat categorization; and prioritization; implemented in protected, unprotected and Hydro – Electric Project areas of Trans, North Western and Western Himalaya; Developed Environment Management Framework for Satluj Basin; Data base on Medicinal, Wild Edible, Essential Oil Yielding and Sacred Plants and Orchids; Documented information on HBRs and data base on NDBR for UNESCO MAB net recognition; Assessed ecosystem services of agro-ecosystems and Sacred Groves; Populations of threatened species, developed Ecological Niche Models; Established and maintained Arboretum and Herbal Garden at Kosi-Katarmal and Arboretum, MPs Nursery, Rural Technology Park and Herbal Garden in Himachal Pradesh; Agrotechniques of 26 MPs documented; Pollination Deficit Protocol for Apple tested, distributed 109 Apis cerana boxes and apiculture equipment to 99 farmers for conservation; Citizen Science Programmes (19) organized; Prepared PBRs for 45 BMCs; installed Manual Weather Stations in 22 Schools for awareness; Trained 10,000 stakeholders, guided 27 students

for Ph.D. and published >330 Papers, Articles, Books, Booklets and Biosphere Reserves (Biannual Bulletin). He is the Elected Fellow of National Academy of Sciences (FNASc), Allahabad and Elected Fellow of the Society of Ethnobotanists (FSE); recipient of Prof. P. N. Mehra Memorial Young Scientist Award; Prof. S. P. Vij Memorial Award; ICFRE, Dehradun Forest Conservation Award; SEED Award; Award of Excellence; Green Mapple Foundation Award; Care Himalaya Award; Rajbhasha Shield and Certificate, etc.; Expert Member of various National, Regional and State Committees and Life Member of various Societies.