Probable Agricultural Biodiversity Heritage Sites in India: II. The Western Himalayan Region[1]

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Abstract

Based on six indices, the warm subhumid to cool-humid Western Himalayan Region, consisting of the Kashmir valley, Himachal Pradesh, and Uttarakhand, could be designated as an Agricultural Biodiversity Heritage Site. *This region is rich in agro-biodiversity, with a large number of species being cultivated. Unique multicrop and horticulture-based farming/production systems have evolved here, based on local resources and socioeconomic conditions, and integrated with human-animal-nature interactions and cultures suited to the diverse landscape that has been created by the various physical factors and micro-geo-climatic variability. Culturally, the site is a mixture of the Indo-Aryan, Mongolian, and Central Asian. Significant species and genetic diversity has evolved as a result of the interaction between the biophysical factors and the landscape, particularly in the case of temperate fruit crops and vegetables, which have a great future in the region.*

Based on the indices illustrated by Singh and Varaprasad (2008) for the identification of probable Agricultural Biodiversity Heritage Sites, the Western Himalayan Region qualifies to be designated as one. Due to a similar warm subhumid to cool-humid climate, a vast area extending from the Kashmir valley in the western Himalayas to the river valleys of Uttarakhand in central Himalayas falls into this category. The site is characterized by high mountains and narrow river valleys with micro-geo-climatic variability diversifying the landscape. From time immemorial, this situation has led the local people to mainly explore the productive interaction with nature, resulting in the cultivation of the largest number of plant species under diverse farming/production systems. The

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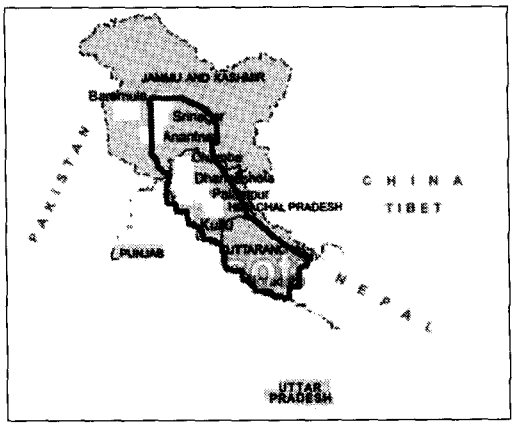

Figure 1. Western Himalayan Agricultural Biodiversity Heritage Site.

rich diversity in temperate fruits, herbs, and topography has led to the dominant practice of horticulture-based and multicropping-based farming systems in Kashmir, Himachal Pradesh, and Uttarakhand, the three Indian states that represent this Agricultural Biodiversity Heritage Site.

Location and extent

The Western Himalayan Agricultural Biodiversity Heritage Site is part of the Himalayas, one of the global biodiversity hotspots. In the north, it is bounded by the cold-arid region of Ladakh, in the west, Pakistan, in the east, Nepal, and in the south, the northern plains of piedmont Himalayas and the Indo-Gangetic region (Fig. 1). It is spread over the districts of Srinagar, Anantnag, Udhampur, Riasi, and Kathua in Jammu and Kashmir, Himachal Pradesh, Siwalik hills of Punjab, and Uttarakhand. It includes most temperate hills and the warm subhumid foothills of the Himalayas.

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Landscape

This site is characterized by high mountains and narrow valleys. The large variation in latitude and availability of moisture throughout the year has promoted the evolution and perpetuation of a rich natural biodiversity. Varying site factors, such as altitude, slope direction, sloping pattern, landraces, temperature, humidity, rainfall, soil factors, available irrigation facilities, and distances from the snowline or plains have resulted in the diversification of the farming landscape. The micro-geo-climatic variability has influenced the diversification of the landscape even within a short distance, affecting the richness of agro-biodiversity as well. Further, inaccessibility, marginality,

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ecological fragility, environmental heterogeneity, locally available resources, and socioeconomic conditions have favored the evolution of diverse but stable farming/ production systems by the local people in a heterogeneous landscape. This landscape variability has also favored the maintenance of rich genetic diversity over centuries.

Agroclimate

The Western Himalayan Region is represented by a cool-humid to warm subhumid climate, with mild summers and cool to cold winters. The mean annual rainfall varies between 1600 and 2000 mm, while the potential evapotranspiration (PET) varies between 800 and 1600 mm, leading to dry-to-moist regimes, ensuring the availability of soil moisture for 150 to 210 days in the year, from April to October, the length of the growing period. The mean annual soil temperature ranges from 15 to 22°C. The major soils occurring in the region are shallow to deep, and have medium to high organic matter content. These are classified as brown forest and podzolic soils. Some such soils are characterized by Gogi-Pather, Wahthora, and Kullu series, which are loamy to loamy/fine in texture, neutral in reaction, and have more than 50% of bases in the exchange complex (Sehgal *et al.*, 1992). Tarai soils (Nainital and Garhwal districts) are deep, loamy, neutral to mildly alkaline, moderately base saturated, high in organic matter, and typically represented by Haldi series.

Floristic diversity

This region has rich floristic diversity, being part of the Himalayas – one of the world's biodiversity hotspots with an estimated 10,000 plant species, of which about 3,160 (71 genera) are endemic. The natural vegetation comprises Himalayan moist temperate, subtropical pine, and sub-alpine forests. The types of natural vegetation in this site are represented by: (i) **Tropical dry deciduous forests** with *Acacia catechu*, *Trema politoria*, *Terminalia bellirica*, *Dalbergia sissoo*; (ii) **Himalayan subtropical pine forest** with *chir* (*Pinus roxburghii*), *Pyrus pashia*, *Terminalia chebula*; (iii) **Subtropical dry evergreen forest** with *Quercus leucotrichophora*, *Morus serrata*, *Rhus punjabensis*; (iv) **Dry temperate forest** with *Cedrus deodara*, *Pinus wallichii*, *Juglans regia*, *Picea smithiana*; (v) **Moist temperate forest** with *Buxus wallichiana*, *Quercus dilatata*, *Populus ciliata*, *Prunus* spp., *Rosa webbiana*; and (vi) **Alpine forest** with *Abies pindrowii*, *Rosa moschata*, *Allium*

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rubellum, Allium stracheyi, Aconitum heterophyllum, Aconitum violaceum.

Agriculture and agricultural biodiversity

The traditional people of the region have been forced to develop dynamic ways of living, predominantly based on agriculture, due to the large variation in altitude and availability of moisture for most part of the year, with inaccessibility, fragility, marginality, landscape heterogeneity, and geo-climatic variability coupled with social, cultural, economic, and political diversity. The main concern of the people has been to productively interact with the nature surrounding them, in order to ensure a comfortable existence. The non-availability of irrigation facilities and distances from the snowline or plains are other driving forces for the diversification of the farming landscape. This variability has favored the harboring of rich species and genetic diversity over centuries. The discrete origin of farm fields is, by and large, complex, but its functional significance would probably be related to the diversified benefit to each family. The existence of discrete parcels has served to maintain crop genetic diversity, and also to largely minimize environmental risk factors and pest control, and ensure use of available resources.

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Most of the area is hilly with plains in the Tarai region. In the valleys, agriculture is mainly practiced on terraced lands. Farmers have traditionally evolved ingenious practices to exploit the available natural resources through productive farming/production systems. Crop yields are totally dependent on the input of locally available organic manure derived from animal dung and urine, forest resources, and crop residues. Farmers leave a substantial portion of the crop residue in the field after harvesting. Plowed back into the field, this residue releases a significant amount of nutrients, which is ultimately reutilized by the subsequent crops. Extensive weeding helps avoid competition, and the uprooted weeds are either left in the field and/or used as animal fodder. In other words, these systems/practices integrate the production system with the human-animal-nature interaction that has been operating since generations. The use of bullocks for draft power and human beings for labor are important inputs into the system. Sharing of human labor through an exchange mechanism has been operating as a tradition, and is a way of stability and equality in society. Men usually perform the heavy tasks such as preparing the farm fields, terraces, and bunds and carrying head loads, whereas women are involved in lighter

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This heritage site falls in one of the three centers recognized for the origin of temperate fruits, the Central Asiatic Center, extending from Tien-Shen South, the Hindu Kush to Kashmir. It is believed that some species of the temperate fruit genera such as *Malus*, *Pyrus*, *Prunus*, *Rubus*, etc. moved to the Himalayas over a period of a few thousand years. They not only survived but established themselves in the hills, leading to the evolution of new species and varieties. Though the cultivation of temperate fruits extends from Jammu and Kashmir to the subtropical plains in the north, the main areas for cultivation fall in the hilly areas, where apple, pear, peach, plum, almond, apricot, sweet cherry, and walnut are traditionally grown. They have commercial significance as they are available for a relatively long period during the year, and thereby contribute significantly to the farmers' income.

Traditionally, rainfed farming is practiced in the valleys and on the terraces. The predominant production systems are rice-based or horticultural plantation crop-based. Paddy and/or horticultural crops such as apple are grown on the terraced uplands. The major crops are rice, wheat, maize, millets, *rajmash* (French bean), chickpea, mustard, etc. In the upper region, barley, mustard, or chickpea follows maize, while in the valleys, pulses follow rice in the rainy season (*kharif*). In Kashmir, rice is a minor crop and is mostly grown in irrigated lands. The major cropping systems in the valley are rice-mustard and rice-oat (fodder). Rice is high-altitude cultivation, both under irrigated and upland conditions. Horticulture-based farming systems are predominant. The important fruits are apple, walnut, apricot, etc. In the Jammu region, the predominant cropping systems are rice-wheat and maize-wheat in irrigated and rainfed areas respectively.

Figure 2. A woman threshing the crop.

Himachal Pradesh has predominantly a traditional mixed farming system, which includes livestock, cereal crops, vegetable crops, and fruits. The traditional mixed-crop farming system accounts for 66% of the total cropped area. These systems rely mainly upon owned resources; it is more sustainable and facilitates conservation of local biodiversity. The recently evolved commercial/market-oriented farming systems, based on vegetables and fruits,

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lean more towards monoculture and depend on forest-based common property resources inputs, and therefore affect biodiversity adversely.

Maize is an important crop in Himachal Pradesh, where rice and wheat are alternate crops. But the region maintains its huge diversity in terms of crops (17), through a variety of crop compositions, cropping patterns, and crop rotations. They can be grouped into cereals (paddy, wheat, and barley), millets and pseudo-cereals (maize, finger millet, amaranths, buckwheat, etc.), pulses (black gram, French bean, horsegram, soybean, mung bean, pea, etc.), vegetables (potato), and oilseed (mustard). Out of the 17 crops, 12 are in general harvested as part of mixed-cropping systems, and confined to the uplands located on terraced slopes during the rainy season (Fig. 3); whereas, wheat, barley, and mustard are usually cultivated as monocrops in winter. Occasionally, wheat is mixed with mustard. Pulses are always intermixed with millets and pseudo-cereals. The number of crops in mixture varies from two to five. Given the high genetic diversity, mixed cropping ensures optimal production under stressful geo-environmental conditions.

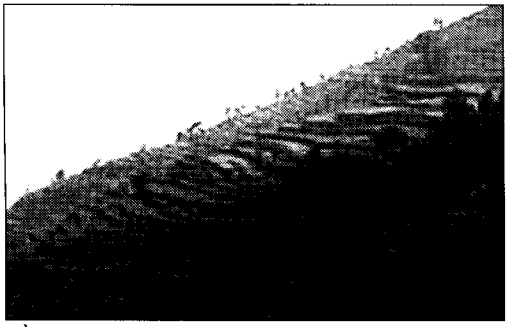

Figure 3. Terrace cultivation on mountain slopes in Himachal Pradesh.

Another unique feature of the traditional farming system is that a large number of plant species are known to be cultivated or economically exploited from nature, as an alternative source of food or for other uses. As many as 25 plant species, including wild edible fruits and seeds, 12 wild vegetables used in sauces and salads, about 10 species used as spices or condiments, and about 15 used as fodder, fuelwood, and timber, are cultivated on private lands. Additionally, a wide variety of herbs used for primary healthcare are cultivated. Some of the common herbs that are traded include *jatamansi* (*Nardostachys jatamansi*), *kutki* (*Picrorhiza kurroa*), *atis* (*Aconitum heterophyllum*), *bankakri* (*Podophyllum hexandrum*), *hathpanja* (*Dactylorhiza hatagirea*), *tagarh* (*Valeriana jatamansi*), and *chora* (*Angelica glauca*); but these are either endangered or becoming increasingly rare.

In Uttarakhand, agriculture is mainly practiced in the river valleys. The farmers have developed advanced manure, crop rotation, and intercropping systems. Three types of agriculture can be found depending on the land type:

1. **Katil,** on forest edge land, with hoe cultivation and a standard rotation of three crops in five years. The main crops are: millet

– *mandua/khoda* (*Eleusine coracana*; finger millet), millet – *jhangora* (*Echinochloa frumentacea*; syn. *Oplismenus frumentaceus*; barnyard millet), and amaranth – *marsa/chua/chaulai* (*Amaranthus polygamous*, *Amaranthus blitum*).

2. **Upraon,** on hillside land, permanently terraced, but non-irrigated. The main crops are: millet (*mandua, jhangora*) and *chaulai*.

3. **Talaon,** on valley bottom land, with paddy cultivation, low-lying, irrigated, double-cropped (Fig. 4). The main crops are: wheat, rice, sugarcane, etc.

As in Himachal Pradesh, various pulses such as *masur* (*Lens culinaris*; lentil) and *kulat* (*Dolichos uniflorus*; horsegram) are grown intercropped in Uttarakhand during the two harvest seasons – early winter after the rainy season (millet) and mid-summer before the hot dry season (barley-wheat). Dry and wet rice, taro, pumpkins, beans, maize, ginger, chili, cucumbers, leafy vegetables, and tobacco are also grown. Potato has become an important cash crop in areas unsuitable for other plants (Berreman, 1963).

Figure 4. Paddy fields in the valley in Uttarakhand.

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In fact multicropping is a way of life, since the ecosystem of the land is fragile, and the climate harsh. For example, a common practice in the Garhwal Himalayas is the cultivation of twelve crops known as "*baranaja*" (twelve grain). The practice of *baranaja* involves sowing of a mixture of crop seeds: *rajmash* (*Phaseolus vulgaris*; French bean, kidney bean), *urad* (*Vigna mungo*; black gram), *mung* (*Vigna radiata*; mung bean, green gram), *kulat* (*Dolichos uniflorus*; horsegram), *ramdana* (*Amaranthus cruentus*; amaranth), *mandua* (*Eleusine coracana*; finger millet), *jhangora* (*Echinochloa frumentacea*; barnyard millet), soybean (*Glycine max*), *lobia* (*Vigna unguiculata*; cowpea), cucumber (*Cucumis sativus*), and *bhang* (*Cannabis sativa*; hemp). Since the harvesting periods of these crops vary, they are harvested at different times, which helps in the retention of soil moisture, and provides a regular supply of foodgrains (Jardhari and

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Kothari, 1996). *Navadanya*, a popular practice of mixed cropping that involves at least nine different cereals, pulses, millets, and different kinds of vegetable varieties (intercropped or mixed cropped), instils general respect for the existence of crop life. In recent decades, it has inspired a movement by the same name, focusing on the conservation of native and indigenous varieties that are fast disappearing. The Navadanya movement advocates the practice of sowing multicrop seeds, to ensure sustainable yields to farmers engaged in promoting species diversity, genetic diversity, and output diversity in farming and rural ecosystems as a whole (Navadanya, 1995). Similarly, bunds along the fields are planted with multipurpose species, such as *Allium auriculatum*, *A. loratum*, *A. roylei*, *A. stracheyi*, *bhimal* (*Grewia optiva*), *Morus serrata*, and *Ficus palmata*, which yield fruits and fodder. Thus the people of the western Himalayas have cultivated and conserved the highest diversity and food production systems compared with any other site.

Crop species

Cultivation of a large number of plant species is a unique feature of the site. The following plant species are cultivated in different crop groups.

Cereals and millets. Rice (*Oryza sativa*), wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), maize (*Zea mays*), oat (*Avena sativa*), rye (*Secale cereale*), millets (*Digitaria cruciata*, *Eleusine compressa*, *Setaria viridis*, *Panicum psilopodium*), *Chenopodium album*, *Amaranthus hypocondriacus*, buckwheat (*Fagopyrum esculentum*), chickpea (*Cicer arietinum*), black gram (*Vigna mungo*), sweet pea (*Lathyrus odoratus*), grass pea (*Lathyrus sativus*), horsegram (*Dolichos uniflorus*), fenugreek (*Trigonella foenum-graecum*), *Flemingia procumbens*, *Flemingia strobilifera*.

Fruits. Indian rough lemon (*Citrus jambhiri*), *karna* (*Citrus karna*), *bihi* (*Cydonia oblonga*), strawberry (*Fragaria vesca*, *F. indica*), walnut (*Juglans regia*), *pista* (*Pistacia vera*, *P. atlantica*, *P. chinensis*), almond (*Prunus amygdalus*, *P. jacquemontii*), apricot (*Prunus armeniaca*), sweet cherry (*Prunus avium*), sour cherry (*Prunus cerasus*), *Prunus jenkinsii*, peach (*Prunus persica*), *Prunus prostrata*, *Prunus tomentosa*, *Prunus wallichii*, pear (*Pyrus communis*), apple (*Malus pumila*), plum (*Prunus domestica*), pomegranate (*Punica granatum*), currant (*Ribes glaciale*, *R. nigrum*), raspberry (*Rubus ellipticus*), *Sorbus aucuparia*, *Sorbus lanata*, mango (*Mangifera indica*), *ber* (*Ziziphus mauritiana*), *Ziziphus oxyphylla*.

Vegetables. Rape seed (*Brassica napus* var. *napus*), black mustard (*Brassica nigra*), cauliflower (*Brassica oleracea* var. *botrytis*), brussels sprouts (*Brassica oleracea* var. *gemmifera*), cabbage (*Brassica oleracea* var. *capitata*), knol-khol (*Brassica oleracea* var. *gongylodes*), turnip (*Brassica rapa*), Simla *mirchi* (*Capsicum frutescens*), Kashmiri *mirchi* (*Capsicum annuum*), cucumber (*Cucumis sativus*), onion

(*Allium cepa*), potato (*Solanum tuberosum*), tomato (*Lycopersicon lycopersicum*), brinjal (*Solanum melongena*; eggplant), okra (*Abelmoschus esculentus*), *Asparagus adscendens*, sugar beet (*Beta vulgaris*), yam (*Dioscorea deltoidea*), artichoke (*Cynara scolymus*), lettuce (*Lactuca sativa*), garden cress (*Lepidium sativum*), sponge gourd (*Luffa aegyptiaca*), French bean (*Phaseolus vulgaris*), radish (*Raphanus sativus*), bladder dock (*Rumex acetosa*), honey plant (*Ammi majus*), saffron (*Crocus sativus*), *heeng* (*Ferula assafoetida*).

Others. Chamomile (*Matricaria chamomilla*), *Trigonella monantha*, mint (*Mentha arvensis*), sugarcane (*Saccharum officinarum*), tea (*Camellia sinensis*).

Other economic plants

Vegetables. *Chorispora tenella* (pods as vegetable), *Coronopus didymus* (fruit as salad), *Crambe cordifolia* (leaves and roots as vegetable), *Cyclanthera pedata* (fruit as vegetable), *Dioscorea sagittata*, *Draba muralis* (salad), *Epilobium palustre* (leaves), *Lepidium capitatum*, *Lepidium draba*, *Lepidium latifolium* (leaves edible), *Lepidium sativum* (leaves as salad), *Malva rotundifolia*, *Malva verticillata*, *Sisymbrium irio*, *Thlaspi arvense* (leaves as vegetable).

Fruits. Chestnut (*Castanea sativa*), hazelnut (*Corylus colurna*, *C. jacquemontii*), *bhutia badam* (*Corylus avellana*), fox-nut (*Euryale ferox*), *Elaeagnus angustifolia*, *Flacourtia indica*, *Flacourtia sapida*, beech (*Fagus sylvatica*), common fig (*Ficus carica*), *Machilus edulis*, *Myrica esculenta*, *Rosa sericea*, *Rosa webbiana*, Java plum (*Syzygium cumini*).

Spices. Black caraway (*Bunium persicum*; syn. *Carum bulbocastanum*), *Cleome icosandra*, caraway (*Carum carvi*), *ajmod* (*Trachyspermum roxburghianum*; syn. *Carum roxburghianum*), burning bush (*Dictamnus albus*) (substitute for tea), *Micromeria biflora* (substitute for tea), black cumin (*Nigella sativa*), parsley (*Petroselinum crispum*), anise (*Pimpinella anisum*), winter savory (*Satureja montana*).

Medicinal and aromatic plants. *Achillea millefolium*, *Aconitum heterophyllum*, *Allium stracheyi*, *Angelica glauca*, *Arnebia benthamii*, *Arnebia euchroma*, *Atropa acuminata*, *Berberis aristata*, *Berberis asiatica*, *Dactylorhiza hatagirea*, *Delphinium denudatum*, *Ephedra gerardiana*, *Nardostachys jatamansi*, *Picrorhiza kurroa*, *Podophyllum hexandrum*, *Potentilla fulgens*, *Rheum australe*, *Rubia manjith*, *Saussurea costus*, *Saussurea lappa*, *Senna sophera*, *Swertia chirayita*, *Taxus baccata* ssp. *wallichiana*, *Valeriana officinalis*.

Timber. Cedar wood (*Cedrus deodara*), pine (*Pinus wallichiana*), *chir* (*Pinus roxburghii*), edible pine (*Pinus gerardiana*), *Pinus sylvestris*, poplar (*Populus alba*), *Populus ciliata*, *Quercus leucotrichophora*.

Dyes and tannins. *Rheum australe*, *Rubia cordifolia.*

Multipurpose species. *Celtis australis*, *Ficus palmata*, *Ficus racemosa*, *Grewia optiva*, walnut (*Juglans regia*), mulberry (*Morus australis*, *M. nigra*, *M. serrata*), *Phoenix acaulis*, *Salix denticulata.*

Bamboo. *Dendrocalamus hookeri* var. *parishii*, *Yushania jaunsarensis.*

Ornamentals. *Calendula arvensis*, pot-marigold (*Calendula officinalis*), cornflower (*Centaurea cyanus*), larkspur (*Delphinium ajacis*), carnation (*Dianthus anatolicus*, *D. cachemiricus*, *D. jacquemontii*, *D. sinensis*), foxtail lily (*Eremurus himalaicus*), iris (*Iris duthiei*, *I. hookeriana*, *I. kashmiriana*), tree jasmine (*Jasminum arborescens*), yellow jasmine (*Jasminum humile*, *J. multiflorum*), spanish jasmine (*Jasminum officinale*, *J. parkeri*, *J. ritchiei*, *J. rottlerianum*), lavender (*Lavandula angustifolia*), wild lily (*Lilium roseum*), water lily (*Nymphaea alba*, *N. caerulea*, *N. tetragona*), rose (*Rosa clinophylla*, *R. damascena*, *R. foetida*, *R. hirsuta*, *R. macrophylla*, *R. moschata*), *Rubia edgeworthii*, *Salvia moorcroftiana*, *Salvia officinalis*, marigold (*Tagetes* spp.), tulip (*Tulipa clusiana* f. *stellata*).

Wild relatives of crop species

Abelmoschus manihot, *Abelmoschus moschatus*, *Abelmoschus tuberculatus*, *Aegilops tauschii*, *Allium altaicum*, *Allium ampeloprasum*, *Allium cernuum*, *Allium chinense*, *Allium fistulosum*, *Allium porrum*, *Allium schoenoprasum*, *Allium senescens*, *Allium tuberosum*, *Avena barbata*, *Avena fatua* ssp. *fatua*, *Avena fatua* ssp. *meridionalis*, *Avena sterilis* ssp. *ludoviciana*, *Cajanus mollis*, *Cajanus scarabaeoides*, *Chenopodium ambrosioides*, *Chenopodium botrys*, *Chenopodium foliosum*, *Chenopodium glaucum*, *Chenopodium hybridum*, *Chenopodium murale*, *Cicer microphyllum*, *Cucumis hardwickii*, *Dioscorea hispida*, *Dioscorea melanophyma*, *Elymus dahuricus*, *Elymus himalayanus*, *Elymus dentatus* ssp. *kashmiricus*, *Fagopyrum cymosum*, *Fagopyrum tataricum*, *Hordeum aegiceras*, *Hordeum brevisubulatum*, *Hordeum distichon*, *Hordeum marinum* ssp. *gussoneanum*, *Hordeum spontaneum*, *Lactuca scariola*, *Linum mysorense*, *Linum perenne*, *Linum strictum*, *Luffa graveolens*, *Malus baccata*, *Malus domestica*, *Mentha piperita*, *Mentha spicata*, *Oryza rufipogon*, *Rubus fruticosus*, *Rubus hypargyrus*, *Rubus lanatus*, *Rubus molucannus*, *Rubus niveus*, *Rubus nutantiflorus*, *Rumex acetosella*, *Rumex patientia*, *Rumex vesicarius*, *Saccharum filifolium*, *Saccharum narenga* (syn. *Narenga porphyrocoma*), *Solanum aculeatissimum*, *Solanum incanum*, *Solanum xanthocarpum* (syn. *Solanum surattense*), *Trichosanthes himalensis*, *Trichosanthes multiloba*, *Trichosanthes tricuspidata*, *Trigonella balanse*, *Trigonella cachemeriana*, *Trigonella emodi*, *Trigonella fimbriata*, *Trigonella gracilis*, *Trigonella podperae*, *Triticum aestivum* subsp. *sphaerococcum*, *Vigna trilobata*, *Vigna umbellata*, *Vigna vexillata* var. *vexillata.*

Endemic species

Acer oblongum var. *membranaceum*, *Aconitum* sp., *Allium chitralicum*, *Allium gilgitcum*, *Allium roylei*, *Atropa acuminata*, *Cicer macracanthum*, *Dendrocalamus hookeri* var. *parishii*, *Indigofera cedrorum*, *Indigofera dosua* var. *simlensis*, *Indigofera gangetica*, *Indigofera himalayensis*, *Iris duthiei*, *Iris hookeriana*, *Iris kashmiriana*, *Juglans regia* var. *kumaonica*, *Lactuca benthamii*, *Lactuca kashmiriana*, *Lilium roseum*, *Lilium thomsonianum*, *Picrorhiza kurroa*, *Podophyllum hexandrum*, *Rosa hirsuta*, *Rosa macrophylla* var. *hookeria*, *Saussurea atkinsonii*, *Saussurea clarkei*, *Saussurea sudhanshui*, *Trigonella podperae* (Table 1).

Threatened species

Acer oblongum, *Allium auriculatum*, *Allium loratum*, *Allium roylei*, *Allium stracheyi*, *Berberis affinis*, *Berberis apiculata*, *Berberis kashmiriana*, *Berberis lambertii*, *Berberis osmustoni*, *Berberis peliolaris* var. *garhealana*, *Berberis pseudoumbellata*, *Berberis royleana*, *Dioscorea deltoidea*, *Lactuca benthamii*, *Lactuca filicina*, *Lactuca undulata*, *Rubus almorensis*, *Saussurea costus*, *Ulmus wallichiana* (Table 2) (Nayar, 1996).

Associated culture and tribes

The people of this site are an admixture of Indo-Aryan and Mongolian races. Historically, the original inhabitants of the Himalayas were the Kinnars, Kilinds, and Kiratas. Hindu epics and the Puranas mention their existence in the Himalayan region. History also mentions the names of Khasas and the Darads. But today only three ethnic groups constitute the Himalayan population. They are the Negroids, Mongoloids, and the Aryans. The Hindus of Indian origin mainly dominate the sub-Himalayan and the middle Himalayan valleys. In eastern Himalayas, again, it is mostly a Hindu population. Muslims are mostly seen in western Kashmir with the cultural influence of Iran and Afghanistan. The main occupation of the people in the Himalayan region is agriculture and animal husbandry. One common tribe that practices agriculture is the Dogries, whereas the Gujars, tend to livestock.

Culturally, the Himalayan region of Kashmir is a zone of convergence and diffusion of mainly three religio-cultural streams, the Muslims, the Buddhists (Tibeto-Mongoloids), and the Hindus. These groups still maintain their regional expression in three distinct parts of the region, with Gilgit, Baltistan, and Poonch, overwhelmingly Muslim, while Jammu is mainly Hindu. The parts of Himachal Pradesh falling in this region are mainly inhabited by the Hindus. The Central Himalayan region has its own distinctiveness, reflecting the sublime blend of Indian cultural traits associated with the Badrinath-Gangotri complex, which has absorbed Mongoloid cults into Hindu molds. Culturally, Uttarakhand Himalaya is largely dominated by the local Pahari (Kumauni and Garhwali) culture in the middle and low altitudes, while in the northern high-altitude valleys, the Bhotia cultural system predominates. The population is predominantly Hindu.

Table 2. Representative agriculturally important species under threat in the Probable Agricultural Biodiversity Heritage Site.

Species	Family	Habit	Threat level[1]	Use
Acer oblongum var. *membranaceum*	Aceraceae	Tree	CR	Wood used for agricultural implements
Aconitum falconeri var. *latilobum*	Ranunculaceae	Herb	VU	Treatment of nervous disorders and digestive diseases
Aconitum kashmiranum	Ranunculaceae	Herb	EN	Medicinal
Allium roylei	Liliaceae	Herb	EN	Culinary
Allium stracheyi	Liliaceae	Herb	VU	Culinary
Atropa acuminata	Solanaceae	Herb	I	Medicinal
Berberis apiculata	Berberidiaceae	Shrub	R	Medicinal
Berberis kashmiriana	Berberidiaceae	Shrub	R	Medicinal
Berberis lambertii	Berberidiaceae	Shrub	R	Medicinal
Dioscorea deltoidea	Dioscoreaceae	Herbaceous climber	EN	Used for washing
Lactuca benthamii	Asteraceae	Herb	EN	Genetic resource
Lactuca undulata	Asteraceae	Herb	EN	Genetic resource
Rubus almorensis	Rosaceae	Shrub	I	Genetic resource
Saussurea costus	Asteraceae	Herb	CR	Medicinal
Ulmus wallichiana	Ulmaceae	Tree	EN	Wood used for furniture

1. CR = Critically endangered; EN = Endangered; VU = Vulnerable; I = Intermediate; R = Rare.

Technology and products

The Western Himalayan Region has a very high level of genetic diversity for the major crops. For example, in Uttarakhand, the *Beej Bachao Andolan* rediscovered over 300 cultivars of rice, 180 cultivars of kidney beans, 30 cultivars of wheat, and 40 of minor millets. The region is known for variability in rice for several desirable features, such as cold tolerance in higher elevations and aroma in valleys. In his Himalayan Gazetteer of 1882, the British official ET Atkinson reported that there were 48 distinct varieties and thousands of nondescript varieties. A large number of traditional varieties of rice have been replaced by a handful of high-yielding varieties (HYVs). The region is geographically associated with the genetic diversity for one of the most popular aromatic rices, called *Basmati* rice, of which *Dehradun Basmati* is known all over the world for its aroma and grain quality. The rice grown in Kashmir is known for cold

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tolerance and blast resistance, with varieties such as Koshar, Shalimar Rice 1, K 332, K 429 in the hills and Jhelum and Chenab regions in the plains. In wheat, the Himachal region is known for variability in initial growth habit, spike emergence, spike/awn length, grain number/spike, spike-awn ratio, and grain uniformity (Singh *et al.*, 2006). Naphal, a local landrace of wheat collected from the higher Himalayan ranges in Uttarakhand, was conserved by the Marcha, a sub-tribal category of the Bhotias, and is known the world over for its soft-milling quality, which makes it ideal for biscuit making. Variability exists in finger millet also, where GE233 from Almora has been identified with low stomata number, low leaf area, and high photosynthetic efficiency.

The region has variability in lentil and peas for seed size, shape, and color, days to maturity, and cold tolerance. Lentil varieties such as VL Masoor 4 and Pant L324 have been selected from a local landrace of Pithoragarh, whereas pea variety VL Matar was selected from a local landrace of Uttarakhand (Singh *et al.*, 2006). In mung bean, the region is known for variability in the number of seeds per pod. Wild forms of rice bean (*Vigna umbellata*) have been reported from the Shimla and Chamba areas (Singh *et al.*, 2006).

Among oilseeds, variability has been reported for brown sarson from the hills of Jammu and Kashmir and Himachal Pradesh. In the case of *Brassica rapa* var. *toria*, the variety Bhawani was developed from a local landrace of Uttarakhand. In soybean, Himachal Pradesh and Uttarakhand are known for a black-seeded landrace called Bhatmash. Varieties such as JS-2 have been developed from a yellow-seeded local landrace from Tehri Garwahl, and Type 41 from another small yellow-seeded landrace (Tiwari *et al.*, 2004). In sesame, local landraces have contributed to the development of varieties such as Type 12 from a landrace from Almora, and Punjab Til No. 1 from a landrace from Kangra (Duhoon *et al.*, 2004). In linseed, Kangra local has been identified as a source of powdery mildew. In the sub-Himalayan region, Dehradun is known for variability in sugarcane for resistance to diseases, tolerance to insect pests, drought, salinity, and waterlogging (Sreenivasan and Amalraj, 2004).

In horticultural crops, the region presents a continuum of variability in indigenous crops such as *Solanum melongena* (eggplant, brinjal), and also in introduced

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crops such as chili. In the case of chili, the variability in landraces has been exploited in the development of varieties Nishat 1 (Sel. 12) and Punjab Mirch 27, with high yield and tolerance to high temperatures in Jammu and Kashmir (Kalloo *et al.,* 2005). Also, in potato, Chamba Red, Kufri Safed, and Kufri Red have been developed through selection from the local cultivar Phulwa (Shekhawat *et al.,* 2005). In cucurbitaceous crops, the region is the center of diversity for cucumber (*Cucumis sativus*), and varieties such as Solan Green have been developed from Solan local. In introduced *Cucurbita moschata,* sufficient variability has evolved to develop a variety such as Sadan Badami from a collection of Himachal Pradesh (Sirohi *et al.,* 2005). Similarly, in the case of spices, rich genetic diversity has been found in ginger and turmeric. In ginger, the variety Himgiri is a clonal selection from Himachal Pradesh.

Kashmir, being part of the Central Asiatic Mountains, one of the three regions for the origin of most temperate fruits (Vavilov, 1951), has native variability in sand pears, wild apricots, local *Prunus* species, almond, walnut, pomegranate, pecannut, hazelnut, and many minor fruits. The systematic characterization and evaluation has resulted in the selection of genotypes that are well adapted to the region. In Kashmir, high-density planting of MM 106 rootstock of superior varieties of apple such as Starkrimson, Oregon Spur, Red Chief, Vance Delicious, and Ambri Selection, with suitable pollinizers such as Gold Spur, Red Gold, and Golden Hornet has been doing well, whereas, in Uttarakhand, Anupam, Chaubattia, Agrim, Chaubattia Swarnima, Red June, and Early Shanburry have been found to be profitable (Prakash *et al.,* 1997). In pear, Red Blush and Punjab Sunehri are examples of superior strains selected from the plantations of Baggugosha (Uppal *et al.*, 1993). In peach, Strak Earliglo, Early White Giant, Starking Delicious, and Candor have been found suitable for cultivation in the mid-hills due to the early-maturing feature. Cultivars Prairie Dawn, Prairie Ramber, and Prairie Rose are suitable for the high-altitude areas of the dry temperate region (Sharma and Kumar, 1994). In plum, Green Gage, Frontier, Kanto5, Kubio, Red Ace, and Tarrol were found promising for the mid-hills (Bist and Sharma, 1996). In sweet cherry, cultivars such as Triumph Domini, Pietro Nigra, Bella Italia, and Foaya Tardiva have been found promising for yield, quality, early maturity, and resistance to insect pests and diseases (Gautam *et al.,* 1992). In strawberry, Chandler, Selva, Douglas, Confictura, Dana, Belrubi, Gorella, Addie, Pajaro, Fern, and Tioga are large-fruited, ever-bearing, and high-yielding selections (Sharma *et al.,* 2005). In almond, Kaul (1990) reported selections HS8, HS9, and HS10 from plantations in Jammu and Kashmir, whereas Tripathi *et al.* (1992) reported that Supernova, Ferragnes, Genco, California Papershell, and IXL were doing well in Pithoragarh. In walnut, Bhat *et al.* (1992) found selection P3 and Wassan 4 from Kashmir suitable for nut and kernel export, respectively. Indigenous seedling selection, such as Solding Selection, Gobind, Roopa Akhrot, and

Kotkhai are also promising for export (Kumar and Sharma, 1995). Rich genetic diversity for certain tropical fruits such as *Citrus* and litchi has been recorded from the sub-Himalayan region. Local communities/farmers have conserved well-known litchi cultivars from Dehradun.

Among the wild relatives found in the region, *Cucumis hardwickii* (from Dehradun) has been identified and used as a source of resistance to powdery mildew and downy mildew, whereas *Cajanus mollis* has been identified with the highest (33.4%) protein content (Remanandan, 1990).

Irrigation systems have also been evolved to facilitate effective use of water. In Jammu and Kashmir, water channel irrigation systems called *Kuls* carry water from the mountains. Similarly, in Himachal Pradesh, systems of channels called *Kuhls* have been developed to divert natural flowing streams (*khuds*). A typical community *Kuhl* services 6 to 30 farmers, irrigating an area of around 20 ha. The *Kuhls* are provided with *moghas* (temporary outlets) to draw out water and irrigate the terraced fields nearby. In Hamirpur, Kangra and Mandi, *Khatris* (structures of about 10 feet × 12 feet and 6 feet deep) carved into the hard rock mountain are used to provide water for the animals, and for washing and drinking. They are owned by individuals and also by the panchayat. The *Naula* surface water harvesting system typically suited to the hills evolved in Uttarakhand. These are small wells or ponds in which water is collected by building a stone wall across a stream.

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Future perspective

The Western Himalayan site is known for horticulture-based systems and has a great future for fruit and vegetable-based agricultural development. This potential can be tapped through further genetic improvement of local cultivars, enrichment of soils, integrated pest management, and establishment of fruit processing-based industries. The predominance of subsistence farming and a fragmented landscape makes the site more suited to low-input organic farming. However, it would need incentives for the use of biofertilizers (i.e., to facilitate use and recycling of farm and forest waste), biopesticides, bio-growth enhancers in addition to integrated pest and good soil management, and removal of subsidies that encourage use of chemical inputs. This would help in restricting the erosion of biodiversity, degradation of soil and environment, and would encourage diversification of food production, ensuring the availability of fruits and vegetables round the year. Agroforestry programs could also be encouraged by offering incentives to farmers. This would reduce the farmers' dependence on common property resources (forests). Additionally, multiple-use sustainable forestry practices

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and afforestation programs should be encouraged.

Deforestation, particularly on slopes, and over-grazing of pastures are causing erosion of plant biodiversity, soils and land destruction, and increasing the stress on forest resources. Therefore, in addition to increase in productivity per unit area through research and appropriate technologies, it is also necessary to restrict the expansion of agriculture, and encourage the regeneration of low-output degraded pastures through reseeding and fertilization. Several combinations and rotations of selected grasses and legumes can be made by planting their pasture species. Awareness regarding the richness of the site, the importance of biological diversity and the social cost of over-exploitation of resources has to be developed along with the concern that more effective action is needed to preserve this invaluable heritage environment.

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