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Probable Agricultural Biodiversity Heritage Sites in India: I. The Cold-Arid Region of Ladakh and Adjacent Areas

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Abstract

The changing global scenario and the amendment of national legislations on ownership over biological resources and intellectual property rights over the indigenous knowledge evolved by the local communities for the useful exploitation of these resources, demands that agricultural biodiversity and indigenous knowledge rich countries like India identify the agricultural heritage sites and document their characteristic features. It would help empowerment of the nation and local communities for their ingenuity and facilitate protection and use. Following the agreement of the UNESCO World Heritage Convention of 1972, an effort has been made to enumerate approaches and indices that can be used for identification of Agricultural Biodiversity Heritage Sites. Using these indices the present article describes the first possible Agricultural Biodiversity Heritage Site in India – Cold-Arid Region of Ladakh and Adjacent Areas. This site is floristically rich with unique biological diversity adapted to the extreme dry and cold climate. The local people have evolved agriculture by diverting glacial-fed rivers into stone-built terraces, gathering soil through sedimentation, enriching the soil with organic manure, and facilitating cultivation of staples to produce surplus food for themselves. The system has been reinforced by the local Buddhist culture that is embodied with strong family and community bonds for sharing the natural resources. The people are self-sufficient, resilient, and exceedingly content. The traditional farming techniques have co-evolved with the culture and have allowed the people to survive both physically and mentally, in what seems to be a completely inhospitable climate. During this process the local people evolved knowledge for management of such harsh environment, developed unique traditional irrigation system, conserved unique landraces of important crops like barley and alfalfa, bred hybrid cow like dzo, *and developed medicinal system* Amchi.

The United Nations Convention on Biological Diversity (CBD), adopted at the 1992 Earth Summit in Rio de Janeiro, changed the world's perception of "biological resources" – from the simple concept of being the *heritage of humankind*, biological

resources are now seen as the *sovereign property* of the nations in whose territory such resources occur. In addition to the protection of biological resources, the provisions of the CBD also require signatory countries to protect and promote the right of the communities, particularly farmers and indigenous peoples, vis-à-vis their customary use of biological and knowledge systems (Articles 8j and 10). Also, as per Article 15.7, the Convention requires the equitable sharing of benefits arising from the commercial use of the communities' biological resourses and local knowledge. It further asserts that intellectual property rights must be supportive of and do not run counter to the objectives of the CBD (Article 16.5). However, the CBD remains silent about the methods to be used to achieve this goal.

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), an international agreement administered by the World Trade Organization (WTO), requires member countries to provide protection to all human innovations, including new plant varieties, through the use of patents or an effective *sui generis* system or a mixture of both (Article 27.1).

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These two international agreements (CBD and TRIPS) have a special bearing on efforts towards the identification and conservation of agricultural biodiversity heritage sites in India.

Throughout the history of agricultural development, human beings have domesticated plants and animals, and shaped even harsh and remote environments to ensure their survival. Generations of farmers have developed ingenious methods to overcome extreme or adverse environmental conditions and scarcity of natural resources. This effort of generations has resulted in the creation of agricultural biological diversity sites with valuable genetic material and cultural inheritance. Also, as this has happened with human intervention, these sites are of great aesthetic value.

However, many of these sites or their components are under severe threat from global development, including changes in human values, climatic changes, rural impoverishment, exodus to urban areas, and competitive global market systems. There is a need to identify and assess these sites for their potential value, before they disappear forever, leaving little or nothing of the natural wealth and priceless knowledge developed over centuries.

The UNESCO World Heritage Convention of 1972 is a unique international instrument for conserving cultural and natural heritage of outstanding universal value. Recently, the Food and Agriculture Organization of the United Nations (FAO) initiated a program on conservation and adaptive management

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of Globally Important Agricultural Heritage Systems (GIAHS), aiming to establish the basis for their global recognition and to promote the conservation and sustainable management of such heritage systems along with their associated landscapes, biodiversity, knowledge systems, and cultures.

India, in response to these international agreements, has promulgated the national *Biological Diversity Act (BDA) 2002*, under Section 37 of which, it has to identify areas of biological diversity importance in the country as *Biodiversity Heritage Sites* (The State Governments are required to do this in consultation with local bodies). Similarly, to meet the requirements of both CBD and TRIPS, India promulgated the *Protection of Plant Varieties and Farmers' Rights Act (PPVFR) 2001 of India*, which has a chapter on farmers' rights (GOI, 2001). It includes the provision of a National Gene Fund for sharing benefits that accrue from the commercialization of the products developed using farmers' material.

In the light of these developments, an attempt has been made to suggest possible approaches and indices that can be used to identify probable Agricultural Biodiversity Heritage Sites, highlighting the valuable components evolved by the farmers' or farming communities in agricultural biodiversity (important for food, fodder, and nutritional security), and the innovative indigenous practices for its promotion, conservation, and sustainable use, ensuring survival over generations (Singh and Varaprasad, 2008). This study proposes some probable Agricultural Biodiversity Heritage Sites that could qualify on the basis of six indices described in this document.

The Indian subcontinent is one of the 12 mega centers of crop diversity (Zeven and Zhukovsky, 1975). It also figures prominently among the Vavilovian centers of origin and diversity of crop plants (Harlan, 1971). Further, of the thirty-four 'biodiversity hot spots' globally identified, three occur in and around the Indian subcontinent, namely in the Himalayas, Western Ghats, and Sri Lanka and the Indo-Burma region. The

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Indian subcontinent is the center of domestication and diversification of several plant species, which include food crops, forages, grasses, forest trees, ornamentals, etc. According to the Botanical Survey of India, 11.9% of the global flora is found in India, including 141 endemic genera belonging to over 47 families of higher plants. As per one estimate, 583 crop plants are cultivated in India (NBPGR, 2000). This includes 168 species earlier reported under the *Hindustani Centre* (one of the eight Vavilovian centers of origin and diversity). These facts suggest that the domestication of economically important plants, and the development of agriculture and its further evolution and spread must have occurred at a number of sites, increasing the likelihood of a number of Agricultural Biodiversity Heritage Sites existing here. Since a single paper would not be able to do justice to the description of all the existing sites, it is proposed to publish information on these sites in a series of papers. The present paper describes the first probable site, starting from the extreme north of the country – the Cold-Arid Region of Ladakh – which has all the proposed indices (characteristics) of agriculture in the region in addition to its floristic richness. The region has unique

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biological diversity adapted to the extreme dry and cold climate, and includes a number of endemic species. Further, the evolution of agriculture has been influenced by the neighboring civilizations, particularly from China and Central Asia, which have enriched agriculture in relation to species and genetic diversity and adoption of certain practices like nomadic agriculture, improving agricultural sustainability and thereby livelihoods.

The Cold-Arid Region of Ladakh

The Ladakh region in the Tibetan Plateau is a high-altitude cold desert under the rain shadow of the Himalayas. To the south lies the Himalayan mountain range; to the north is the Karakoram mountain range; to the west, Kashmir; and to the east lies Tibet. Since the region lies in the rain shadow, it is one of the driest places on earth. Under these harsh conditions agriculture is difficult. Nevertheless, by diverting glacial-fed rivers into stone-built terraces, gathering soil through sedimentation, enriching the soils with organic manure and other practices, the local people have been able to cultivate staples. Therefore, traditional Ladakh agriculture is unique and is representative of the Tibetan plateau.

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Location and extent

This heritage site is located in the upper limits of the western Himalayas, extending from Leh to Nubra Valley and Gilgit district (Fig. 1) and covering some parts of the high reaches of Himachal Pradesh, such as Lauhal Spiti and Dorras. It encompasses the cold-arid region of India, and is characterized by mild summers and extreme winters.

The landscape

Towering mountain peaks covered with snow represent most of the landscape (Fig. 2). The region has been called Ladakh, meaning *Land of the High Passes*, which is apt because of the multitude of towering mountain ranges, river valleys, and high plateaus. The Karakoram Range isolates the northern border and contains the highest peak in Ladakh, *Saser Kangri*, at 7,672 m (25,164 ft). The Himalayan Range along the southern and eastern border contains two 7,000-m peaks, *Nun* and *Kun*. Other popular

Figure 1. Cold-Arid Region: Ladakh, Nubra Valley, and Gilgit district.

Figure 2. A common landscape of agricultural fields in Ladakh.

peaks are *Stok Kangri* (6,121 m) in the Stok Range, and *Kang Yatse* (6,401 m) in the Zanskar Range. Routes over the high passes of Ladakh were established centuries ago by the caravan traders and the local people. Some of these routes have now been developed into motorable roads. The world's highest motorable road from Leh to the Nubra Valley crosses the *Kardung La* at 5,602 m (18,375 ft). The road from Kargil to Padum in the Zanskar Valley must pass over the *Fentse La* at 4,450 m (Bhasin, 1992).

Several major river systems flow through the region. The mighty Indus River enters Ladakh in the east, from its origin near Mount Kailas in Tibet, and flows westward into northern Pakistan, then flows down south to the Arabian Sea near Karachi. The Indus forms a broad valley about 10 km wide between the Ladakh and Stok Ranges near Leh. In Zanskar, located between the Zanskar and Himalayan Ranges, the Stod and Tsarap Rivers join to form the Zanskar River, which eventually cuts deep gorges in the Zanskar Range and flows into the Indus River at Nimoo. The Shyok River flows south from its origin in the Aksai Chin and then turns northwest, flowing between the Ladakh and Karakoram Ranges. Its tributary, the Nubra River, originates in the Saichen Glacier and gives its name to the valley. The Suru River flows in western Ladakh before joining the Drass River at Kargil, and flowing into Kashmir.

Also, the high plains of eastern Ladakh contain several large brackish water lakes. The largest is the Pangong Tso lake, which extends into Tibet. The Rupshu plains to the south contain the lakes Tso Moriri and Tso Kar.

Agroclimate

The Ladakh region has short mild summers and severe winters. The temperatures range from −19°C to 33°C, with mean temperatures between 9°C and 11°C, and the annual mean soil temperature less than 8°C. The annual rainfall is less than 150 mm, while PET (potential evapotranspiration) is 700–800 mm, leading to a highly dry moisture regime. The precipitation covers only 15% of the total PET, with a very short growing season of about 60 days that can get extended up to 90 days. Agriculture is mainly confined to the valleys, which have shallow skeletal calcareous soils that are alkaline in reaction and are low in organic matter; the rest of the region is cold desert with sandy soils.

Floristic diversity

The region is rich in rare floristic species, being part of one of the world's biodiversity hot spots, the Himalayas (which contain an estimated 10,000 species of plants, of which about 3,160, belonging to 71 genera, are endemic). Some 1,195 species of flowering plants are endemic to the Western Himalayas (Misra and Gokhale, 2003) of which 700 plant species have been recorded from this region. The extreme climatic conditions have resulted in less natural vegetation, with sparse shrubs and trees.

There are three main elements of floristic diversity: alpine, desertic, and oasitic. The alpine herbs grow along the edges of melting glaciers. The desertic type covers the upper slopes and valleys, and comprises trees such as *Juniperus* L., *Acer* L., *Populus*, *Salix* L., *Elaeagnus* L., and *Prunus* L. along the river margins. Other common plants are *Polygonum affine* Steph. ex Sprang., *Trollis acaulis* Lindl., *Primula rosea* Royle, *Taraxacum officinale* Weber, *Anaphalis nepalensis* (Sprang.) Hard. Mazz., and *Anemone tetrasepala* Royle. The mountainous regions are largely covered by *Astragalus-Oxytropis-Acantholimon*, with xeric plants such as *Acantholimon* spp., and *Artemisia* spp., and steppe plants such as *Scorzonera virgata* DC., *Tananetum* spp., etc. decrease in abundance with increase in altitude. Other common elements are *Capparis spinosa* L., *Chenopodium* spp., *Corydalis adiantifolia* Hook.f. Thomson, *Dianthus anatolicus* Boiss., *Euphorbia tibetica* Boiss., *Inula* sp., *Lactuca tatarica* (L.) C.A.May., *Malcolmia* sp., *Matthiola* spp., *Nepeta floccosa* Benth., *Peganum harmala* L., etc. The Zanskar Range at about 3,880 to 4,150 m has a belt of *Betula utilis* D.Don, *Abies*, *Juniperus*, and *Pinus wallichiana* A.B. Jacks. Vast areas are under *Artemisia-Astragalus-Acantholimon* cover. A gradual increase in elevation is accompanied by a decrease in desertic elements such as *Chenopodium* and *Heracleum pinnatum* C.B. Clarke. The river banks and streams also support shrubs of *Hippophae rhamnoides* L. and *Rosa moschata* Herrm. (Misra and Gokhale, 2003). A number of herbaceous plant species have been used for medicinal properties and

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play an important role in the traditional medicinal system called *Amchi* developed by the local people.

Agriculture and agricultural biodiversity

The traditional agriculture practiced by the farmers of the region has generated important knowledge about unique adaptations of the crop species that have allowed the people to survive in this high-altitude desert. Despite the short growing period, absence of rainfall, and harsh climate, the Ladakhi people have developed a range of farming systems and produce more than enough food for themselves. This is achieved through a complex network of irrigation canals and an interesting method of fertilizing soils, evolved over generations. The region represents an excellent example of the creativity and adaptability of traditional farmers, which have enabled them to practice all the available components of agriculture even in an extreme climate (Richards, 1985).

Traditional agriculture in Ladakh has been based on human labor, animal power, and handmade tools. Fields are irrigated with glacial melt water and fertilized with human "night soil". Families maintain small vegetable gardens and sometimes apple or apricot orchards, and keep a few animals such as goats, sheep, mules, and *dzo* (a cross between a yak and a local breed of cow). The technologies practiced are simple, yet, in the four months between the spring and autumn frosts, people produce more than enough food for the entire year, gallons of *chang*, the local beer, and surplus for trade or to purchase other requirements such as salt, tea, jewellery, etc. This system has been reinforced by the local culture and tradition (Buddhist) that is embodied with strong family and community bonds, which provides a deep sense of psychological security in working together for peace and harmony. By all measures, the traditional culture with respect to nature has been extremely successful in supporting agriculture, which is ecologically friendly, sustainable, and is very important, as it supports people's livelihoods. Therefore, the traditional farming techniques have co-evolved with the culture and have allowed the people to survive both physically and mentally, in what seems to be a completely inhospitable climate.

There is almost no rainfall in the region; therefore all water is supplied from glacier-fed streams and rivers. Over the centuries, the local people have developed a wide

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network for harnessing the water from the rivers and snow-melt streams to feed elaborate irrigation systems. The rivers are diverted into small canals that carry the water, sometimes for several kilometers. These canals are further divided into smaller channels, so that each small plot has its own established water supply. There is also almost no naturally occurring soil suitable for agriculture. The soil is actually developed by the people. The basic terraced structures of the fields are built from stone. In the spring, people stand in the rivers and disturb the river bottom with long poles or rakes, which forces the river sediments into the water. The sediment-laden water is directed to the new fields, where it floods the stone-enclosed terraces. The sediments are allowed to settle into the soil, and then the process is repeated. This process is actually undertaken on established fields as well to add fresh supplies of minerals and nutrients. Once enough river sediments have been deposited, usually after several years of controlled flooding, early succesionist species of plants are encouraged to grow. Small grasses and the vibrant Himalayan rose usually dominate this phase. The rose bushes are eventually cut and used as fencing; their thorny branches being one of the few things animals will not push through to get at the crops. As the soils improve over time, willow trees are planted in the next phase and eventually used as building material. When the plot of land is deemed ready, human and animal manures are mixed with the soil and the staple crop of barley is planted. The Ladakhis have developed small-scale farming systems adapted to this unique environment. About two-thirds of the plots are planted with barley; the remainder is used to raise wheat, buckwheat, pea, etc., establishing field-crop-based farming systems, or family plots of turnips, potatoes, tomatoes, and lettuce to practice vegetable-based horticulture farming system. In the valleys at lower elevations, orchards are also maintained to practice fruit-crop-based horticulture, in which the main trees are apricot, with a few apple and walnut trees. Along river valleys, particularly along water channels, on slopes and field bunds, tree species such as *Salix alba* L., *Populus ciliata* Wall., and *Juniperus* are cultivated as part of agroforestry with a social touch. This has been a recent successful introduction.

Ladakhi farmers produce nearly all the necessary inputs on their own farms. Human and animal wastes are mixed with inedible crop residues. After composting, this rich organic matter is applied to the fields. As previously mentioned, the soils are also enriched with a great deal of minerals and nutrients from flooding. These techniques ensure that the farmers are highly self-sufficient and do not depend on external inputs.

The heavy snowfalls in winter not only provide sufficient water supply to the farmers, but also allow grasses and other plants to grow at the higher elevations.

These are being maintained as pasture lands to provide good grazing lands for yaks, sheep, and goats to facilitate livestock rearing.

The thawing period of July–September, when there are scanty rains, is the cropping season. Crops such as barley are sown in May and reaped in mid-July. The growing time varies considerably with altitude. It starts with the sowing of crops such as barley, wheat, buckwheat, pea, and alfalfa in the valleys. Horticulture crops are sown among the field crops and winter vegetables. The field crops are cultivated on special stone-built terraces. Since it is difficult to grow grain crops, more forage crops such as lucerne are grown. Among the horticultural fruit crops, apples and apricot are grown in the lower parts of valley on slopes or along the water streams. Generally, much of the farm or fieldwork extends up to July, when the crops are sown; very little work is undertaken in August, when the only crops that may be ready for harvest are garden vegetables. Late August is when the alfalfa and barley are harvested in some villages, or picking of apricots, begins in earnest. The extreme climate results in a leisurely pace of work (except at peak harvest time) in the fields and in the households, with frequent breaks throughout the day.

The main crop is barley, which is roasted and ground into a powder called *tsampa*. This is the staple food of Ladakh. The barley is also used to make local beer called *chang*. Other crops are wheat, vegetables, mustard, apples, and apricots. The second major source of nourishment is yak butter, which is mixed with *tsampa* and rolled into balls, or mixed with tea and salt and consumed in the form of the famous yak butter tea. Yak cheese is also consumed.

Animals are also an important component of Ladakhi subsistence agriculture. The Ladakhis raise sheep, goats, horses and their revered *dzo*, which is their most important draft animal as well as their primary source of milk, cheese, and wool. In Ladakh, the higher altitude pastures are in fact more productive. Therefore, the community appoints one or two members of the village to take all the animals to higher pastures. There, while the animals graze, the attendants spin wool, make butter and cheese and collect dung for the winter. Additionally, the high-altitude Rupshu region is the reserve of nomadic herders for nomadic agriculture practiced by certain tribes, such as the *Changpa*, who are pure Tibetans, and were probably the first herders to have settled in Ladakh. These diverse farming systems ensure relatively constant food production from season to season and from year to year. Fresh vegetables ripen in the summer, apples and barley are ready in the fall, and animals yield fresh dairy produce all round the year. Additionally, livestock are an insurance against extremely harsh growing seasons and are killed for meat if the crops fail.

The surrounding natural ecosystems support very low species diversity, as Ladakh is a high-altitude desert where virtually nothing grows. However, traditional farming systems have been able to promote both species and genetic diversity. The landscape in a traditionally farmed area is a patchwork of different vegetation types created by the

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various farming systems. The result is a variety of ecological niches that encourage biological diversity. The landscape, in these intensively managed areas, is a mosaic of cultivated, grazed, uncultivated, and successional lands. The introduction and evolution of farming systems at these heritage sites (valleys), therefore, have actually enriched the biodiversity of the area and increased the complexity of the ecosystems. This is quite evident from the lush and green irrigated valleys, with most strata covered with diverse systems of agriculture. Without the involvement of the farmers, these valleys would be as barren as the surrounding desert. Traditional farmers in the tropics maintain trophic complexity approaching natural systems. Ladakhi farmers actually surpass the trophic complexity of their surroundings.

Agro-ecosystem research must examine farming/production systems from a broad social perspective in order to understand how a particular system has evolved (Altieri, 1987). The complex interaction of cultural and environmental factors is readily apparent when examining Ladakhi society and their farming methods. The people are self-sufficient, resilient, and exceedingly content. The harsh environment greatly limits what can be grown. Yet, even under these constraints, people are able to produce enough food for themselves, and to trade the produce for tea or salt, or to brew vast quantities of *chang* (needed for frequent winter celebrations). In large part, the credit for this goes to their Buddhist culture, which encourages people to respect the land and the community. It teaches people to appreciate what they have, to avoid conflict, to live in harmony with their neighbors and their environment. It is difficult to determine if their culture and values actually evolved in response to the limitations imposed upon them by the environment, or for the effective management of a harsh and extreme environment. What is evident is that, despite the limitations of their environment, they have very successfully developed a culture and innovative system of agricultural production that is extremely well adapted to these limitations. Ladakh is a truly self-sufficient culture. Almost everything is produced locally by necessity. It is for this reason that Ladakh is of importance from an agro-ecological perspective. The following paragraphs outline the major representative plant species that are important from an economic point of view, or as genetic resources to be used in the genetic improvement of cultivated species.

Crop species. Barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L.), buckwheat (*Fagopyrum esculentum*

Moench), pea (*Pisum sativum* L.), chickpea (*Cicer arietinum* L.), fenugreek (*Trigonella foenum-graecum*), alfalfa (*Medicago sativa* L.), winter vegetables such as cauliflower (*Brassica oleracea* var. *botrytis* L.), cabbage (*Brassica oleracea* var. *capitata* (L.) DC.), turnip (*Brassica rapa* L. ssp. *rapa*), rapeseed mustard (*Brassica napus* L.), onion (*Allium cepa* L.), apple (*Pyrus communis* L.), apricot (*Prunus armeniaca* L.), and sea-buckthorn (*Hippophae rhamnoides* L.).

Other economic plant species. *Juniperus communis* L., *Juniperus indica* Bertol, *Populus deltoides* Bartram ex Marshall, willow (*Salix alba* L.); and medicinal plants such as *Atropa* L., *Dioscorea* Plum ex L., *Ephedra* L., etc.

Medicinal plants. *Aamokh* (*Macrotomia* sp.), *akjenta* (*Echinops cornigerus* DC.), *banafshah* (*Viola biflora* L.), *batkatel* (*Solanum xanthocarpum* Schard. & H.Wendl.), *bisho* (*Clematis alpine* (L.) Mill.), *bugsukkang* (*Vicia sativa* L.), catnip (*Nepeta floccosa* Benth.), *chargospsz* (*Delphinium* Tourn. ex L.), *chhmumasseo* (*Lactuca lessertiana* C.B. Clarke), *chumbi tiki* (*Gentianella* sp.), *demok* (*Arnebia euchroma* I.M. Johrist.; *A. guttata* Bunge), *denmo-kusoo* (*Podophyllum hexandrum* Royle), *dianko* (*Astragalus* sp.), *drakspose* (*Biebersteinia* sp.), *gatils* (*Bergenia stracheyi* (H.K.) Engl.), *jang* (*Ephedra gerardiana* Wall.), *jungli pudina* (*Mentha longifolia* L.), *kabra* (*Capparis spinosa* L.), *khampa* (*Artemisia laciniata* Willd.; *A. macrocephala* Jacquem. ex Less.), *khilchakarpo* (*Plantago himalaica* Pilg.), *koniet* (*Carum bulbocastanum* W.Koch.), *krelseng* (*Astragalus rhizanthus* Royle), *kumblik* (*Carum carvi* L.), *kuth* (*Gentiana decumbens* L.f.), *lungna* (*Aster tibeticus* Hook.f.), *magrass* (*Artemisia biennis* Willd.), *mechanserpo* (*Inula obtusifolia* A. Kern.; *I. royleana* DC.), *padam* (*Juniperus macropoda* Boiss.; *J. excelsa* M.B.), *paleyoung* (*Sisymbrium* L.), *phagun* (*Hyoscyamus niger* L.), *phansi* (*Saussurea bracteata* Decne), *Picrorhiza kurroa* Royle ex Benth., *pizareena* (*Cousinia* sp.), *ralchat* (*Corydalis govaniana* Wall.), *reskunsemar* (*Cremanthodium arnicoides* R.D.Good), *sache* (*Artemisia dracunculus* L.), *sah kuchlas* (*Bupleurum* sp.), *shinnar* (*Berberis ilicinia* Hook.), *skial daepo* (*Potentilla argyrophylla* Wall. ex Lehm.), *skiche* (*Allium carolnianum* DC.), *spangsea* (*Saussurea* sp.), *tikta* (*Jaeschkea oligosperma* Knobl.), *umpre* (*Myricaria elegans* Royle), *yangcher* (*Cirsium arvense* (L.) Scop.), *zema* (*Erodium tibetanum* Edgew. & Hook.f.), and *zieo* (*Artemisia japonica* Thunb.) (Kaul, 1997). Additionally, around 70 species have been listed for their potential value as medicinal herbs (Uniyal, 2006).

Wild relatives. *Allium carolnianum* DC., *A. chitralicum* Wang & Tang, *A. gilgitcum* Wang & Tang, *A. rubellum* M. Bieb., *Cicer macracanthum* M. Pop., *C. microphyllum* Benth., *Fagopyrum cymosum* (Trevir.) Meisn., *F. tataricum* (L.) Gaertn., *Hippophae rhamnoides* L., *H. salicifolia* D. Don, *Hordeum glaucum* Steud., *H. spontaneum* Koch., *H. turkestanicum* Nevski, *Populus alba* L., *P. angustifolia* E. James, *P. candicans* Aiton, *P. ciliata*

Schur., *P. deltoides* Bartram ex Marshall, *P. euphratica* Oliv., *P. nigra* L., *Salix alba* L., *S. denticulata* Anderss., *S. elegans* Host., *S. fragilis* L., *S. sclerophylla* Anderss., *S. wallichiana* Anderss., *Trigonella emodi* Benth., *T. podperae* (Širj.) Vassilcz, and *Triticum aestivum* L. ssp. *sphaerococcum* (Percival) Mackey.

Endemic species. *Aconitum deinorrhizum* Stapf, *A. heterophyllum* Wall ex Royle, *A. kashmiricum* Stapf ex Caventry, *A. violaceum* Jacquem. ex Stapf var. *robustum*, *Allium gilgitcum* Wang & Tang, *Aquilegia fragrans* L., *Arnebia* Forssk., *Atropa accuminata* Royle, *Cicer microphyllum* Benth., *Dianthus jacquemontii* Edgew, *Hippophae rhamnoides* L., *Meconopsis aculeata* Royle, *Potentilla* L., and *Saussurea clarkei* Hook.f. (Table 1) (Nayar, 1996).

Threatened species. *Aconitum violaceum* Jacquem., *A. heterophyllum* Wall ex Royle, *Arnebia benthamii* (Wall ex G.Don) Johns, *Arnebia* sp., *Artemisia absinthium* L., *A. maritima* Thunb., *Atropa acuminata* Royle, *Bergenia ligulata* Engl., *Dactylorhiza hatagirea* (D.Don) Soó, *Dioscorea deltoidea* Wall ex Griseb., *Ephedra gerardiana* Wall ex Stapf., *Fritillaria roylei* Hook., *Heracleum candicans* Wall. ex DC., *Herminium monorchis* R.Br., *Inula racemosa* Hook.f., *Lavatera* L., *Meconopsis aculeata* Royle, *Physochlaena* K.Koch, *Picrorhiza kurroa* Royle ex Benth., *Podophyllum hexandrum* Royle, *Rheum emodii* Wall ex Miesn., *Rheum webbian* Royle, *Saussurea costus* (Falc.) Lipsch., *S. obvallata* (DC.) Sch. Bip., *Taxus wallichiana* Zucc., and *Valeriana wallichii* DC. (Table 2). In addition, the Field Research Laboratory, Leh, of the Defence Research and Development Organisation, and the Divisional Forest Officer, Leh, have listed some more medicinal plant species to be under threat (Misra and Gokhale, 2003).

Associated culture and tribes

The area is predominantly inhabited by the Tibeto-Mongoloid race with the influence of Buddhist culture/religion. The traditional culture of Ladakh evolved from Tibetan Buddhism. Evidence of this can be found in the many, centuries old monasteries that are found in almost every village throughout Ladakh. Large numbers of monks look after the religious and spiritual needs of the people, and are the most respected members of society. Most Ladakhi homes, and even the tents of the nomads, have a small chapel containing various religious objects and sacred images. Other visible signs of the Buddhist faith are prayer flags, stupas, and Mani walls.

Ladakh has a blend of different races, predominantly the Tibetans, Mons, and the Dards. People of pure Dard descent predominate in the Dras and Dha-Hanu valleys. The residents of Dha-Hanu, known as *Brokpa*, are followers of Tibetan Buddhism and have preserved much of their original Dardic traditions and customs. The Dards around Dras, however, have converted to Islam and have been strongly influenced by their Kashmiri neighbors. The Mons are descendants of earlier Indian

Table 1. Representative agriculturally important species endemic to the probable Agricultural Biodiversity Heritage Site.

Plant species	Family	Habit	Distribution	Remarks
Aconitum deinorrhizum	Ranunculaceae	Herb	Alpine zone, along slopes	Roots are medicinal
Aconitum heterophyllum	Ranunculaceae	Herb	Northwestern Himalayas	Medicinal
Aconitum kashmiricum	Ranunculaceae	Herb	Northwestern Himalayas	Roots are medicinal
Aconitum violaceum var. *robustum*	Ranunculaceae	Herb	Northwestern Himalayas	Roots are medicinal
Allium gilgitcum	Alliaceae	Herb	Northwestern Himalayas	Wild relative, spice
Aquilegia fragrans	Ranunculaceae	Herb	Northwestern Himalayas	Homoeopathic medicine
Arnebia benthamii	Boraginaceae	Herb	Northwestern Himalayas	Tonic
Atropa acuminata	Solanaceae	Erect herb	Northwestern Himalayas	Medicinal, wild relative
Cicer microphyllum	Fabaceae	Herb	Ladakh	Wild relative
Dianthus jacquemontii	Caryophyllaceae	Herb	Alpine Himalaya	Ornamental
Hippophae rhamnoides	Elaeagnaceae	Shrub	Northwestern Himalayas	Minor fruit
Meconopsis aculeata	Papaveraceae	Herb	Northwestern Himalayas	Medicinal
Potentilla brevsicissa	Rosaseae	Herb	Northwestern Himalayas	Medicinal
Saussurea clarkei	Asteraceae	Herb	Northwestern Himalayas	Medicinal

settlers in Ladakh. They work as musicians, blacksmiths, and carpenters. In Kargil and the Suru Valley, the population is predominately Baltis. This area was part of Baltistan until 1947. They have Tibetan origins, but were converted to Islam in the 15th century and the majority of them are Shiite Muslims. There are some Sunni Muslims of Kashmiri descent around Leh and also Padum in Zanskar. There are also small numbers of followers of the Bon religion, Hinduism, Sikhism, and Christianity.

Table 2. Representative agriculturally important species under threat at the probable Agricultural Biodiversity Heritage Site.

Plant species	Family	Habit	Threat level	Remarks
Aconitum heterophyllum	Ranunculaceae	Herb	Endangered	Medicinal
Arnebia euchvoma	Boraginaceae	Herb	Endangered	Medicinal
Atropa acuminata	Solanaceae	Herb	Indeterminate (insufficient data)	Medicinal
Bergenia ligulata	Saxifragaceae	Herb	Indeterminate (insufficient data)	Roots have great medicinal value
Dactylorhiza hatagirea	Orchidaceae	Herb	Critically endangered	Orchid with medicinal value
Dioscorea deltoidea	Dioscoreaceae	Herbaceous climber	Endangered	Used for washing
Ephedra gerardiana	Ephedraceae	In rain shadow of the Greater Himalaya up to 3,700–5,300 m	Indeterminate (insufficient data)	Ephedrine is a salt of an alkaloid; used in asthma, and in Ayurvedic preparations
Meconopsis aculeata	Papaveraceae	Herb	Critically endangered	
Picrorhiza kurroa	Scrophulariaceae	Herb	Endangered	
Podophyllum hexandrum	Berberidaceae	Herb	Endangered	Rhizomes and roots have medicinal value

Most Buddhists follow the tantric form of Buddhism known as Vajrayana Buddhism. The people of Tibetan descent with some Dardic and Mon admixture, the Balti and Purigs, are believed to have more Dardic ancestry than the Ladakhis. The *Changpa* nomads, who live in the Rupshu plateau, are pure Tibetans, and it was probably herders like them who first settled in Ladakh and Baltistan. Muslim Arghons, descendants of Kashmiri or Central Asian merchants and Ladakhi women mainly live in Leh. The appearance and lifestyle of both central and Eastern Ladakhis and Zanskaris reflect a strong influence from Central Tibet, which diminishes westwards, being replaced by that of the Dards. The Baltis of Kargil, Nubra, Suru Valley, and Baltistan, however, show strong Tibetan links in their appearance and language, and were Bonpa and Buddhists until recent times.

With its history as a trading center on the old caravan route, the valleys such as Leh

have a mixture of cultures living and working together. It has influenced agriculture and the food habits, such as the introduction of pea and chickpea among crops, and tea in Ladakh, which is traditionally made with strong green tea, butter, and salt as in Central Asia; it is mixed in a large churn and known as *gurgur cha*, after the sound it makes when mixed. The most recent contributors to this cultural mix are the Christian missionaries and the Indian Armed Forces, who introduced the growing of vegetables like potatoes, tomatoes, cauliflower, and spinach. They also introduced the method of storing root vegetables in underground chambers to extend their edible life.

Technology and products

The traditional Ladakh agriculture is unique and representative of the Tibetan plateau. In addition to traditional agricultural practices, the region provides rare knowledge of management of natural resources and cultivation of suitable crops under severe cold-arid climatic conditions. The traditional agricultural practices consist of diverting glacial-fed rivers into stone-built terraces, where soil is formed; further addition of manure facilitates the planting of staples such as barley. The farmers have been conserving landraces of cultivated plants with reservoirs of genes, especially for crops such as barley and alfalfa, which are of global importance. Rich genetic diversity has been collected from Ladakh for necked (hull-less) barley (Verma *et al.*, 2006). Naked barley has been used as staple food and also for making a local beverage called *chhung*. Low temperature regimes restrict plant growth – the growing period is very short, and soils are shallow, sandy, and poor in organic matter with nutritive imbalance. However, successful agricultural practices and systems developed with the ingenuity of the local communities enable the practice of a variety of farming systems that meet diverse requirements. It has enabled exploiting to the fullest the short thawing period, which coincides with the rainy season, and fertilizing the soil with human and animal excreta in valleys, facilitating cultivation of selected crop species.

Over time, the local communities have contributed significantly to the conservation of high altitude plant biodiversity in pasture lands and to the development of indigenous knowledge regarding their potential value, particularly the medicinal value, which has resulted in the establishment of a local medicine system called *Amchi*. In addition, recent cultivation and exploitation of sea-buckthorn (*Hippophae rhamnoides*) has led to the development of various products from its fruits, which have contributed significantly to the region's economy.

In animal husbandry, Ladakhis have been able to breed the revered *dzo*, a cross between a yak and a cow to fulfill their dairy requirements. Also, they have conserved rare and endangered species such as the *chiru*, or Tibetan antelope (Ladakhi: *tsos*), which has traditionally been hunted for its wool known as *shahtoosh*, valued for its light weight and warmth and as a status symbol.

Ladakhi villagers have developed the traditional irrigation system in which the

stream coming down from the glaciers is tapped with the help of small channels. The water is diverted to small tanks called *zing* and then used for irrigating the fields. Each village has a vast network of canals and *zings*. Effective distribution of water is ensured by the *churpun*, a village official.

Weaving is another important part of traditional life in eastern Ladakh. Both women and men weave on different looms. Typical costumes include *Gonchas* of velvet, elaborately embroidered waistcoats and boots, and hats.

For the above reasons, this region has been declared as one of the Globally Important Agriculture Heritage Systems (GIAHS).

Future perspective

The region's valleys have great potential for the plantation of dry fruit crops such as apricot, off-season vegetables such as pea, and for the seed production of some of the commercial temperate crops such as potato and onion. Local species diversity can be commercially exploited, for example the *Rosa* species is used for the cultivation of ornamental roses during summer, which offers the local farmers another avenue to increase their income. This not only meets the requirement of the Indian market, but also has great export potential. Systematic and science-based production, use and popularization of the local medicine system and herbal medicines can also contribute to improving the local economy.

For centuries, Ladakh has enjoyed a stable and self-reliant agricultural economy based on growing barley, wheat, and pea, and keeping livestock, especially yak, *dzos*, cows, sheep, and goats. Farmers can be advised to practice on-farm conservation and genetic enhancement of traditional varieties, which can lead to productive genetic diversification; and the development of diversity that is useful and appropriate for traditional farmers and adapted to local growing conditions. Therefore, in situ conservation needs to be promoted to ensure that control remains in the hands of the farmers who will manage the crops while being a constant stimulus to more productive agriculture.

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