

Probable Agricultural Biodiversity Heritage Sites in India: III. The Eastern Himalayan Region*

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Abstract

The Eastern Himalayan Region has been proposed as another National Agricultural Biodiversity Heritage Site, based on six indices. The region is the richest in species diversity among the northeastern states of India. It is the center of diversity for several widely distributed plant taxa and a crucible for speciation encompassing several primitive families. It has the largest number of wild relatives of economically important plant species in India, particularly of crop species. Because of variation in elevation and landscape, the region practices diverse farming/production systems with specialization in some of the agroforestry systems, such as the cardamom-based production system in Sikkim, and the valley cultivation of rice in Arunachal Pradesh, integrated with pisciculture. The wild relatives of crop species offer a reservoir of new genes for exploitation, whereas the diversity of species (particularly those with potential floriculture value, such as orchids and rhododendrons) offer new alternatives to local farmers to improve their income. Though the region faces several problems – such as sloping terrain, difficult access, depletion of natural resources, water scarcity in the lean season and heavy rain and soil erosion during the monsoon – the diverse agroclimate created by the variation in elevation offers a great future for agriculture with improved scientific research, as well as attractive business avenues for the production of seeds of temperate crops in collaboration with seed companies.

The Eastern Himalayan Region, consisting of Arunachal Pradesh, Sikkim, and the hills of West Bengal, with its unique natural landscape and age-old culture has been proposed as one of the Agricultural

Biodiversity Heritage Sites, based on the indices illustrated by Singh and Varaprasad (2008). The area has been identified as part of a global hotspot of biodiversity, as a center of diversity for several widely distributed

* The accuracy of the botanical names of plant species, and the authorities mentioned in the article is the sole responsibility of the authors. (Eds.)

taxa such as rhododendron, and for the development of unique farming systems suited to the diverse landscapes/ecologies of the region. Most people in the region are employed in agriculture. In Sikkim, agriculture is practiced on terraced fields created on steep hill sides. This area is known for its agroforestry land use system, involving cardamom cultivation.

In Arunachal Pradesh, the Apatanis have been regarded as one of the relatively advanced tribal societies perfected in the valley cultivation of rice over centuries, which involves practices such as recycling of crop residue and organic wastes to sustain soil fertility, and the cooperative system to facilitate optimum use of water along with nutrients under the overall supervision of the village headman, thereby

harmonizing the functioning of the valley land agroecosystem. The region inherits a unique culture that believes in the conservation of the entire landscape, which is considered sacred, facilitating the harmonious coexistence of man and nature. This article discusses these aspects in detail, justifying the proposition of the Eastern Himalayan Region as a global Agricultural Biodiversity Heritage Site.

Location and extent

The region encompasses the eastern Himalayan warm perhumid ecoregions with brown hill soils, which extends to most of Arunachal Pradesh and Sikkim, and the northern tip of West Bengal (Darjeeling and Kalimpong) (Fig. 1). The state of Sikkim lies sandwiched between the kingdoms of Nepal

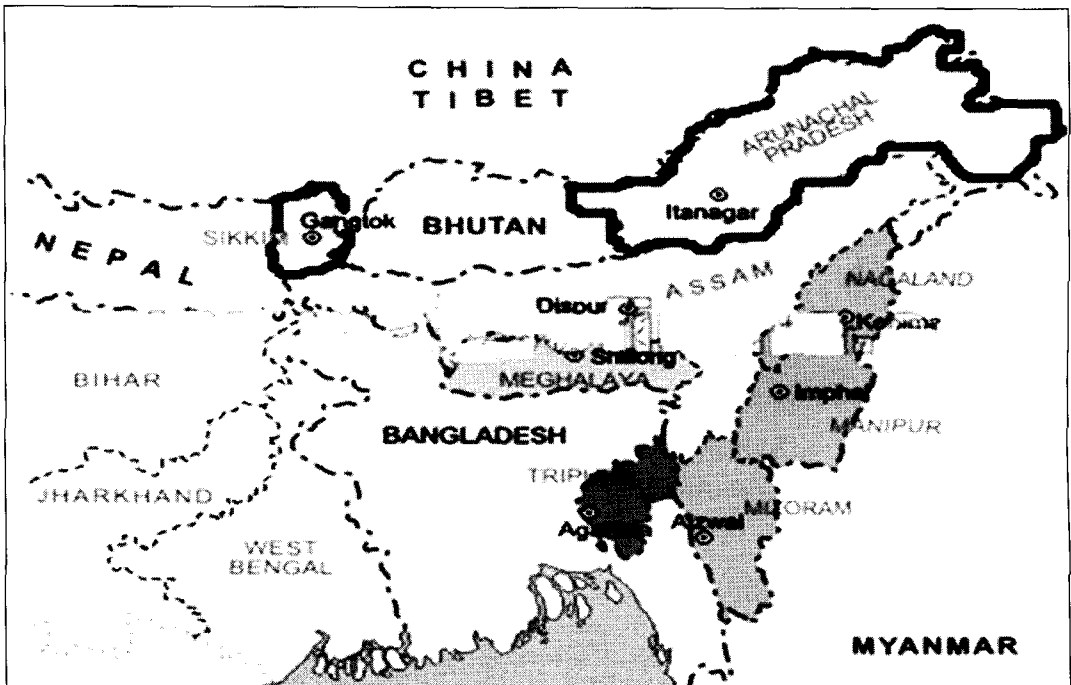


Figure 1. Location and extent of the Eastern Himalayan Region.

The Eastern Himalayan Region, consisting of Arunachal Pradesh, Sikkim, and the hills of West Bengal, with its unique natural landscape and age-old culture has been proposed as one of the Agricultural Biodiversity Heritage Sites.

in the west and Bhutan in the east, with the plateau of Tibet towering along its northern border. In the south, Sikkim shares its border with West Bengal. Arunachal Pradesh shares its border with Assam in the south and Nagaland in the southeast. Myanmar (Burma) lies towards the east, Bhutan towards the west, and Tibet towards the north. Arunachal Pradesh is also known as the “land of the rising sun”, being the easternmost state of India. Biogeographically, it is situated in the Eastern Himalayan Province, the richest biogeographical province of the Himalayan zone.

Landscape

The landscape consists of high mountains, glaciers, passes, and valleys. Sikkim is like a stupendous stairway leading from the western border of the Tibetan plateau down to the plains of West Bengal, with a fall of about 5,215 m in 240 km. In the west, it is bound by the north-south spur of the Great Himalayan range, which includes the world's third highest peak, Khangchendzonga. Down to its south is the Singalila Ridge. In the north, it is bound by the Dongkia range, which includes the Tibetan Plateau, and in the east it is bound by the Chola range. The average steepness is

about 45 degrees. Sikkim is the main catchment area for the beautiful river Teesta, which has its main source from the Chho Lhamo Lake in the north. It is further strengthened by many streams and rivers, of which Tholung, Lachung, Great Rangeet, and Rangpo are the important drainers. It also has about 180 perennial lakes, among which Khachoedpalri, Gurudongmar, Chho Lhamo, and Men Moi Tso are known for their extreme scenic beauty.

Similarly, Arunachal Pradesh presents a complex hill system with varying elevations ranging from 50 m in the foothills, gradually ascending to about 7,000 m, and traversed throughout by a number of rivers and rivulets. Much of Arunachal Pradesh is covered by the Himalayas. However, parts of Lohit, Changlang, and Tirap are covered by the Patkai Hills. Kangto, Nyegi Kangsang, the main Gorichen peak and the Eastern Gorichen peak are some of the highest peaks in this region of the Himalayas. Patkai Bum Hills are low mountains compared to the Greater Himalayas. The principal rivers are Kameng, Siang, Lohit, Tirap, Subansri, and Dibang.

Agroclimate

Being a hilly region, the climate varies with the elevation. Areas that are at a very high

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elevation in the Upper Himalayas, close to the Tibetan border, enjoy an alpine climate. The Middle Himalayas have a temperate climate, and the areas at the sub-Himalayan and sea-level elevation generally experience a humid subtropical climate, along with hot summers and mild winters. Hence, the agroclimatic condition ranges from tropical to subtropical in the lower valley, to alpine in the upper reaches. Nevertheless, in general, the climate of the region is characterized by moderate-to-severe winters and mild summers. The mean annual rainfall exceeds 2,000 mm, while potential evapotranspiration (PET) is only 800–1,000 mm, leading to the availability of sufficient moisture for the major part of the year, extending the growing period to more than 270 days. Arunachal Pradesh receives a comparatively higher rainfall of 2,000 to 4,000 mm annually, most of it between May and September. Water stress is experienced only during postrainy season.

The region has shallow-to-medium loamy, brown forest soil, and deep, organic-matter-rich, Tarai soils (in the foothills). The region is typified by a Udic soil moisture regime. The soil temperature varies from 18 to 22°C. These soils are strong to moderately acidic in nature (Sehgal *et al.*, 1992).

Floristic diversity

The region is very rich in floristic diversity, being part of the Himalaya – one of the world's Global Biodiversity Hotspots, with an estimated 10,000 plant species, of which about 3,160 (71 genera) are endemic (www.biodiversityhotspots.org/xp/Hotspots/himalaya/Pages/biodiversity.aspx). This region falls in the meeting ground of the Indo-Malayan and the Indo-Chinese

biogeographical realms. Also, it has elements of the Himalayan and Peninsular Indian region that has given rise to a very rich biodiversity, both in wild and cultivated landscapes. Arunachal Pradesh and Sikkim have been reported to be the richest in terms of floral species among the northeastern states of India; they contain 5,000 and 4,500 species respectively, 60% of which are endemic (Chatterjee *et al.*, 2006). The Eastern Himalaya is also a center of diversity for several widely distributed plant taxa, such as *Rhododendron*, *Primula* Linn. fide Kuntze, and *Pedicularis*. The Eastern Himalaya is part of one of the biodiversity hotspots of the world, considered as a crucible of speciation, due to the presence of the phylogenetically primitive families such as Magnoliaceae, Eupteleaceae, Tetracentraceae, Lardizabalaceae, and Hamamelidaceae. For this reason, it is also considered as a center of “living fossils”. Several widely distributed plant taxa with high endemism have been reported from genera such as *Gentiana*, *Primula*, *Pedicularis*, *Rhododendron*, *Saxifraga*, etc.

As the region has vast variation in altitude (ranging from 300 to 8,585 m) within very short distances, the elevation has played a prime role in designing the ecoregional diversity. According to altitude variations, the region broadly has four zones of vegetation: tropical, subtropical, temperate, and alpine and trans-Himalayan. But in some stray areas, altitude alone may not define a zone as exposure to other physical properties of the terrain can result in variation otherwise. The dominant natural vegetation comprises of subtropical pine forests and wet evergreen temperate forest.

The tropical zone lies between 300 m (with low river valleys) and 1,200–1,800 m (the mid-hill heights). The topographical features of this zone are deep valleys and gorges with well-drained slopes. The tropical evergreen forest has canopy trees (30–50 m tall) such as *Dipterocarpus retusus* Blume, *Shorea assamica* Dyer, and *Terminalia myriocarpa* Van Heurck & Müll. Arg. The valley area has an abundance of sal forests (*Shorea robusta*). Beneath the canopies of the tall evergreen and semi-deciduous trees, the dense undergrowth in this belt includes various species of orchids, *Rhapidophora* sp. (aroid), wild banana, pandanus, nettles, and giant bamboo.

The subtropical region ranges from about 1,800 m to 3,000 m, and consists of high hills with high rainfall, which keeps the zone humid throughout the year. The subtropical semi-evergreen forests are represented by tall trees (30–40 m) of *Acrocarpus fraxinifolius* Wight & Arn., *Artocarpus lakoocha* Roxb., and *Canarium strictum* Roxb., whereas subtropical forests are dominated by *Alnus nepalensis* D. Don, *Callicarpa arborea* Wall., *Magnolia pterocarpa* Roxb., etc. In addition, the vegetation consists mainly of *Castanopsis hystrix* A.DC. (chestnut), *Machilus* Nees spp. (*kawla*), *Rhododendron* spp. (*chimal*), *Symplocos spicata* Roxb. (*kholme*), *S. theifolia* D. Don (*kharane*), *Michelia excelsa* Kuntze (magnolia), *Quercus lamellosa* Sm. (Himalayan oak), *Quercus lineata* Blume (*phalant*), *Leucosceptrum canum* Sm. (*ghurpis*), *Quercus pachyphylla* Kurz (*sungure katus*), *Betula alnoides* Buch.-Ham. (*saur*), *Nyssa javanica* Wangerin (*lekh chilaune*), and

Bucklandia populnea R.Br. ex Griff. (*pipli*). In the underwood, the predominant species are *Engelhardtia spicata* Blume (*mahuwa*), *Eurya japonica* Thunb. (*jhingni*), *Rhododendron arboreum* Sm. (*gurans*), and *Viburnum* L. spp. (*asare*). In the evergreen forests, oak and rhododendrons predominate. The upper storey consists of *Quercus lamellosa* Sm. (Himalayan oak), *Q. lineata* Blume (*phalant*), and *Machilus* Nees spp. (*kawla*), whereas the undergrowth consists of *Arundinaria maling* Gamble (dwarf bamboo), dwarf rhododendron, ferns, epiphytic moss, and orchids.

The temperate and alpine zone extends from 3,000 to 4,000 m, with mixed coniferous forests of hemlock, spruce, pine, fir, and juniper, and with a shrubby undergrowth of rhododendron and dwarf bamboo. Temperate broad-leaved forests are represented by *Acer hookeri* Miq., *Betula alnoides* Buch.-Ham., *Quercus glauca* Martrin-Donos & Timb., and *Magnolia campbellii* Hook.f. & Thomson; and temperate coniferous forests, by associations of *Tsuga dumosa* Eichl., *Pinus roxburghii* Sarg., *Rhododendron* spp., *Abies Spectabilis* Spach, *Taxus wallichiana* Zucc., *Picea spinulosa* (Griff.) Beissn., *Larix griffithiana* Carrière, etc. Pine forests are

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represented by *Pinus roxburghii* Sarg., *P. wallichiana* A.B.Jacks., and *P. merkusii* Jungh. & de Vriese. The alpine forests and scrub extend up to 4,500 m with small crooked trees and large shrubs interspersed with fir and pine. The trans-Himalayan region lying between 4,500 m and 5,500 m is characterized by cold desert vegetation, restricted to the north of Sikkim. This region has not been included in the protected area network and therefore has a large number of species under threat (www.questhimalaya.com/moreabout/sikkim-biodiversity.htm).

Agriculture and agrobiodiversity

Jhum (shifting cultivation) has been the traditional farming system of the region, practiced from ancient times. Most farming is rainfed. Most of the human population of the region resides in the tropical and subtropical zones, in an agricultural setting with improved system of terrace cultivation of rice, vegetables and other horticultural and floricultural crops growing in valleys (Fig. 2), besides their cultivation in homestead gardens. Besides growing crops in irrigated or unirrigated fields, other agricultural land-use activity includes agroforestry, horticulture, and animal husbandry (including nomadic).

The alpine agropastoralism farming system is commonly practiced in high-altitude areas, under which yak, sheep, and cattle rearing is



Figure 2. Slope management and upland rice cultivation.

practiced with grazing in forest pasturelands as the main occupation. The main products are meat, wool, cheese, etc. Medicinal plants and species such as *Hippophae* spp. are also collected for diverse uses. In the temperate and alpine zones, subsistence farming is also practiced with the cultivation of wheat, barley, and maize. Beans, peas, apple, peach, and pear are grown in homesteads, while potato and cabbage are grown as cash crops. The traditional agroforestry system predominantly involving cultivation of large cardamom (*Amomum subulatum* Roxb.) is practiced in Sikkim (Fig. 3). This spice has good storing/keeping quality and does not require immediate marketing. Fifty-three percent of



Figure 3. Traditional large cardamom agroforestry.

The subtropical region ranges from about 1,800 m to 3,000 m, and consists of high hills with high rainfall, which keeps the zone humid throughout the year. The subtropical semi-evergreen forests are represented by tall trees (30–40 m).

the total world production of large cardamom is produced by the farmers of Sikkim with earnings of about US\$ 15 million (www.jsps.go.jp/english/e-plaza/e-sdialogue/03_data/Dr_Sharma.pdf). Other cropping systems are characterized by cultivation of cereals and cash crops, including vegetables, to ensure a supply of food grains and returns for daily needs. Crop diversity is high and crop combinations are well-tested and fixed in these systems. In field crops, upland valley rice cultivation is dominant, which has resulted in the evolution of a large number of local landraces. In this system, pulses, beans, and soybeans are grown on the raised bunds. The “Barah Anaaj” (twelve different types of food grains) system of crops strengthens the inseparable relation between farming and livestock. The crops give valuable straw and husk for animal consumption. Unpalatable grasses are used for composting by mixing them with cow dung to meet the high demand for manure, thereby exhibiting the practice

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of an efficient recycling system of plant material.

In the improved terrace system (in which terraces are created on steep hillsides), rice is the most important crop. The Apatani tribe of Arunachal Pradesh has developed and perfected valley cultivation of rice over centuries, achieving the maximum output/input ratio (Fig. 4). For this reason, they have been considered one of the relatively advanced tribal societies of the region. Like other farming systems of wet rice cultivation, their system also suffers from nutrient washout; however, the recycling of crop residues, and the use of organic wastes of the village and pig dung, have been effective in restoring soil fertility. The Apatanis can also be credited with the establishment of a cooperative system under the overall supervision of the village headman, for the optimum use of water along with nutrients in their rice fields, with specially designed bamboo tubing to facilitate irrigation and nutrient application. The Apatanis sow early varieties farther away from the village on soils with lower nutrient status, and late

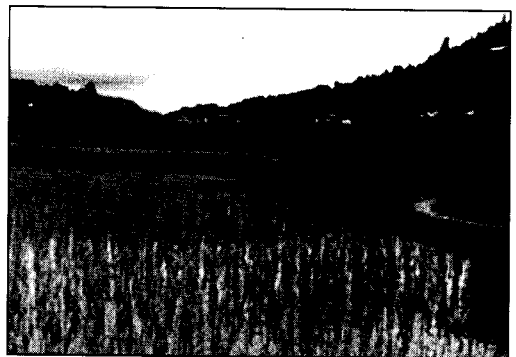


Figure 4. A terraced plot under rice-fish farming in the Apatani plateau, Arunachal Pradesh.

varieties on soils closer to the village, which are nutritionally richer with favorable conditions for combining with pisciculture (Kumar and Ramakrishnan, 1990). Fish culture practiced in the system synchronizes well with late-ripening rice varieties (Das, 2002). Further, rice is supplemented with finger millet (*Eleusine coracana* Gaertn.), cultivated on elevated partition bunds between the rice plots. With human labor as the major input (both men and women participating), the Apatanis obtain a high energy output with exceptionally high energy efficiency (60 to 80 units per unit energy input), with an output/input ratio of 4–18 (Ramakrishnan, 1992). It is far superior to the traditional wet cultivation of rice practiced anywhere in the world. Other cereals such as maize and millets, and potato and sesame are also grown on terraces. The cropping systems followed are: rice-mustard/toria, rice-sesame, maize-mustard/toria, and rice-potato.

In Sikkim, the principal horticultural crops include large cardamom, ginger, turmeric, orange, apple, pear, and off-season vegetables and flowers such as gladiolus,

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orchids, lilies, gerbera, carnation, and anthurium for both cut flowers and planting materials. Large cardamom occupies the largest area of about 24,000 ha of the total cropped area. It is a perennial cash crop grown beneath the forest cover on marginal land (Fig. 3). Hence, it is well fitted in the agroforestry system of land use. Forests and large cardamom agroforestry conserve more soil compared to other land uses. Interventions, such as cultivation of broom grass upon terrace risers and *Albizia Durazz.* trees in large cardamom agroforestry and croplands contribute to maintaining soil fertility. The ginger available in Sikkim is less fibrous with high moisture content and suitable for the manufacture of ginger products such as preserves, candy, crystallized ginger, ginger biscuits, etc. Sikkim grows a special chili locally known as 'Dalle Khorsani'. It has good aroma with considerable pungency.

In plantation, mandarin fruit orchards with intercropping at the base are common. In Sikkim orange is the important crop in respect of area and production. The other fruits grown are apple, pear, litchi, and passion fruit. Tea and coffee are the other two plantation crops that generate revenue

for the region's economy. In floriculture, the important flowers, which are well adopted, are gladiolus, carnation, gerbera, orchids, and zanthadesia. Wild edibles such as bamboo shoot, ferns, and nettles are also collected from forest areas during season.

In addition to plantations of large cardamom beneath canopies of tall trees in forest patches and terraced farmland, multiple intercropping, multipurpose tree management, and mixed farming agriculture system are also common in the natural landscape. Trees are maintained on the farms mainly for fodder and rarely for fuel purposes. Areca nut is becoming another important commercial plantation crop of the region, besides tea (estate at Temi) and the well-nurtured exotic *Cryptomeria japonica* D. Don tree that were introduced to the region around a century ago. They have now become the dominant features of the landscape.

Representative plant species in various crop groups

Cereals, pseudocereals, and millets.

Amaranth (*Amaranthus hypocondriacus* L.), barley (*Hordeum vulgare* L.), buckwheat (*Fagopyrum esculentum* Moench, known as 'mite phapar'; *F. tataricum* Gaertn., known as 'tite phapar'), *Chenopodium album* Bosc. ex Moq., finger millet (*Eleusine coracana* Gaertn.), maize (*Zea mays* L.), proso millet (*Panicum miliaecum* L.), rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.).

Grain legumes and oilseeds. Adzuki bean [*Vigna angularis* (Willd.) Ohwi & H. Ohashi], black gram [*V. mungo* (L.) Hepper], *Brassica* spp., lablab bean [*Lablab purpureus* (L.) Sweet], French

bean (*Phaseolus vulgaris* L.), *Hodgsonia heteroclita* Hook.f. & Thomson, kudzu vine (*Pueraria edulis* Pamp.), niger [*Guizotia abyssinica* (L.f.) Cass.], pigeonpea [*Cajanus cajan* (L.) Millsp.], perilla (*Perilla frutescens* L. ex B.D.Jacks.), rice bean [*Vigna umbellata* (Thunb.) Ohwi & H. Ohashi], sesame (*Sesamum indicum* L.), soybean [*Glycine max* (L.) Merrill.], sword bean [*Canavalia gladiata* (Jacq.) DC.], white mustard [*Brassica alba* (L.) Rabenh.], winged bean (*Psophocarpus tetragonolobus* DC.).

Fibers and forage. Fiber – cotton (*Gossypium arboreum* L.), jute (*Corchorus capsularis* L.), mesta (*Hibiscus cannabinus* L.); forage – *Desmodium kulhaitense* C.B. Clarke, *D. triquetrum* (L.) DC., *Digitaria cruciata* Nees ex Hook.f., khunju (*Lespedeza cuneata* G. Don), *Pueraria lobata* (Willd.) Ohwi subsp. *thomsonii* (Benth.) H. Ohashi & Y. Tateishi, *Pueraria sikkimensis* Prain, *Pueraria tuberosa* DC., *Stylosanthes guianensis* (Aubl.) Sw., white clover (*Trifolium repens* L.).

Vegetables and tubers. Bitter gourd [*Momordica charantia* L., *M. cochinchinensis* (Lour.) Spreng.], Brussels sprouts (*Brassica oleracea* L. var.

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gemmifera Zenker), cabbage [*B. oleracea* L. var. *capitata* (L.) DC.], cauliflower (*B. oleracea* L. var. *botrytis* L.), chayote [*Sechium edule* (Jacq.) Sw.], *Chenopodium album* L., cucumber (*Cucumis sativus* L.), garden cress (*Lepidium sativum* L.), garlic (*Allium sativum* L.), kakora (*Momordica dioica* Roxb. ex Willd.), amaranth (*Amaranth* spp.) (leafy vegetable), Indian lettuce (*Lactuca indica* L., *L. sativa* L.) (leafy vegetable), *Rumex acetosus* St Lag., onion (*Allium cepa* L.), *Rheum nobile* Hook.f. & Thomson (young shoots eaten), ridge gourd [*Luffa acutangula* (L.) Roxb.], *L. aegyptiaca* Mill., snake gourd (*Trichosanthes anguina* L. var. *cucumerina* L.), red pumpkin (*Cucurbita maxima* Lam.), squash (*C. moschata* Duchesne ex Poir.), pumpkin (*C. pepo* L.), sticky nightshade (*Solanum sisymbriifolium* Lam.), turnip (*Brassica rapa* L.); tubers – elephant-foot yam [*Amorphophallus paeonifolius* (Dennst.) Nicolson], giant taro [*Alocasia macrorrhizos* (L.) G.Don], taro (*Alocasia indica* Schott), taro/elephant-ear yam [*Colocasia esculenta* (L.) Schott, *C. fallax* Schott], yam [*Dioscorea alata* L., *D. bulbifera* L., *D. esculenta* (Lour.) Burkill, *D. kamoonsensis* Kunth, *D. japonica* Thunb., *D. lepcharum* Prain & Burkill, *D. wightii* Hook.f.].

Spices. Areca nut (*Areca catechu* L.), Bengal cardamom (*Amomum aromaticum* Roxb., *A. dealbatum* Roxb.), black pepper (*Piper nigrum* Lam. ex Link), cardamom (*Elettaria cardamomum* Maton), *Curcuma latifolia* Rosc., *Fraxinus floribunda* Wall. (gum obtained from the stem used for

sweetening), galangal (*Kaempferia galanga* L.), mouse garlic (*Allium angulosum* Krock.), shell ginger [*Alpinia malaccensis* Roscoe, *A. zerumbet* (Pers.) B.L.Burtt & R.M.Sm.], ginger (*Zingiber officinale* Roscoe), greater (or large) cardamom (*Amomum subulatum* Roxb.), long pepper (*Piper longum* L.), Japanese cinnamon (*Cinnamomum pauciflorum* Chun ex H.T.Chang), *dalchini* (*Cinnamomum pedunculatum* J. Presl, *C. zeylanicum* Blume), *C. tamala* (Buch.-Ham.) T.Nees & C.H.Eberm., turmeric (*Curcuma longa* L.).

Fruits. Apricot (*Prunus armeniaca* Blanco), fig (*Ficus carica* L.), Himalayan hazel (*Corylus ferox* Wall.), Himalayan black raspberry (*Rubus rugosus* Sm.), Himalayan yellow raspberry (*R. ellipticus* Sm.), Indian crab apple (*Docynia hookeriana* Decne., *D. indica* Decne.), karna orange (*Citrus karna* Raf.), lemon [*C. limon* (L.) Burm.f.], lime [*C. aurantifolia* (Christm.) Swingle], mandarin (*C. reticulata* Blanco), mango (*Mangifera indica* L.), plantain (*Musa superba* Roxb.), peach (*Prunus persica* Stokes), sand pear or China brine (*Pyrus pyrifolia* Nakai), Sikkim strawberry (*Fragaria daltoniana* J.Gay), *Sorbus himalaica* Gabrielian, *S. microphylla* Wenzig, *S. vestita* (Wall. ex G.Don) S.Schauer., sweet lime (*Citrus limettioides* Tanaka), *turanj* (*C. medica* L. var. *medica*).

Other plantation and dye-yielding plants. Chebulic myrobalan (*Terminalia chebula* Willd. ex Flem.), *raltam* (*Calamus* L. spp.), sugarcane (*Saccharum officinarum* L.), tea (*Camellia sinensis* Kuntze), toddy

palm (*Caryota urens* L.), tree cotton (*Gossypium cuminatum*); dye-yielding plants – *Bixa orellana* (fruits), *Dichroa febrifuga* (fruits), *Indigofera* L. spp., *Mahonia nepalensis* (bark), *Rumex nepalensis* Spreng. (roots), *Symplocos glomerata* King ex C.B.Clarke (leaves).

Other economic plants

Minor vegetables. Bamboo (*Dendrocalamus hamiltonii* Nees & Arn. ex Munro) (edible shoots), *Cissus repens* Lam., vegetable fern [*Diplazium esculentum* (Retz.) Sw.], *Gymnopetalum quinquelobum* Miq. (edible fruits), *meello karela* (*Cyclanthera pedata* Schrad.), scarlet runner bean (*Phaseolus coccineus*).

Minor fruits. *Capparis pachyphylla* M. Jacobs, *Coriaria nepalensis* Wall., *Drypetes assamica* Pax & K.Hoffm., fig (*Ficus pomifera* Kurz), *Holboellia latifolia* Wall., jack fruit (*Artocarpus heterophyllus* Lam.), *kawla* (*Machilus edulis* King ex Hook.f.), monkey jack fruit (*Artocarpus lakoocha* Roxb.).

Less-known beverages. *Diplospora singularis* (dried and roasted leaves as a substitute for coffee), *baunra* (*Eurya arunachalensis* G.S.Giri, G.D.Pal & T.K.Pal).

Medicinal plants. Barberry (*Berberis asiatica* Roxb. ex DC., *B. umbellata* Wall ex D.Don var. *branii* Ahrendt, *B. dasyclada* Ahrendt), *baunra* (*Eurya arunachalensis* G.S.Giri, G.D.Pal & T.K.Pal), *Bupleurum sikkimensis* P.K.Mukh. (also spice), chebulic myrobalan (*Terminalia chebula* Willd. ex

Flem.), chiretta [*Swertia chirayita* (Roxb.) Buch.-Ham. ex C.B.Clarke, *S. ramose* W.W. Smith, *S. rex* Clarke], common yew (*Taxus baccata*, *T. wallichiana* Zucc.), costus (*Costus speciosus* Sm.), curculigo (*Curculigo orchioides* Gaertn.), *dharu harida* (*Berberis aristata* DC.), gold thread (*Coptis teeta* N.Wallich), *Gentiana pluviarum* W.W. Smith, *G. glabriuscula* Harry Sm. ex T.N.Ho, *Hypericum williamsii* N.Robson, Indian podophyllum (*Podophyllum hexandrum* Royle, *P. sikkimense* R.Chatterjee & Mukerjee, *P. emodii* Wall ex Honigberger), juniper (*Juniperus communis* L.), mishmi aconite (*Aconitum lethale* Griff.), *Panax sikkimensis* R.N.Banerjee, *Picrorhiza kurroa* Royle ex Benth., quinine (*Cinchona officinalis* L.), *Saussurea andersonii* Clarke, *S. forrestii* Diels, *S. gossypiphora* Wall., *S. nimborum* W.W. Smith, *S. pantlingiana* W.W. Smith, *Zanthoxylum burkillianum* Babu.

Timber. *Albizia lebbeck* (L.) Benth., *Castanopsis indica* Roxburgh ex Lindley, *cheer* (*Pinus kesiya* Royle ex Gordon, *P. roxburghii*, *P. wallichiana*), Japanese cedar (*Cryptomeria japonica* D.Don), Himalayan cypress (*Cupressus torulosa* D.Don), *Dipterocarpus retusus* Blume (timber and resin), Nepalese alder (*Alnus nepalensis* D.Don.), oak (*Quercus acutissima* Carruth., *Q. lamellosa* Sm.), sal (*Shorea assamica*), East Indian almond (*Terminalia myriocarpa* Van Heurck & Müll.Arg.), Indian mahogany (*Toona ciliata* M.Roem.), Himalayan hemlock (*Tsuga dumosa* Eich.), walnut (*Juglans regia* L.).

Multipurpose species. *Falsa* (*Grewia oppositifolia*), *Ficus cunia*, *Hippophae* spp., *khorial* (*Parkia timoriana*; syn. *P. roxburghii*), mulberry (*Morus alba* L., *M. australis* Poir) (fruit and rearing silk worm), wild tea-rose (*Rosa gigantea* Collett ex Crép.) (rose hip juicy, edible, and ornamental).

Bamboos. Dwarf bamboo (*Arundinaria maling*), *Bambusa arundinacea* (Retz.) Willd., *mala bans* (*B. nutans* Wall. ex Munro), *pareng* (*Cephalostachyum hookernia* Gamble), *singhani bans* [*Chimnobambusa hookeriana* (Munro) Nakai], *nigala bans* (*C. intermedia*), *Dendrocalamus calostachys* Kurz., *D. giganteus*, *D. hamiltonii* Nees, *D. sahnii* H.B.Naithani & Bahadur, *D. sikkimensis* Gamble ex Oliv., *D. strictus* Nees, *Gigantochloa auriculata* Kurz, *Melocalamus gracilis* W.T.Lin, *M. mastersii* (Munro) R.B.Majumdar, *Neomicrocalamus manni* (Gamble) Ohrnb., *N. clarkei* (Gamble ex Brandis) R.B.Majumdar, *Pseudostachyum polymorphum* Munro, *Schizostachyum seshagirianum* R.Majumdar, *S. capitatum* (Munro) R.B.Majumdar, *S. griffithii* (Munro) R.B.Majumdar, *tshi* or *kishome bans* (*Thamnocalamus gostratus*).

Ornamentals. The region inhabits a large number of orchid and rhododendron species, which have attracted the most attention from naturalists, primarily because these plants produce attractive flowers in many colors and shapes. Some orchid and rhododendron species are: *Bulbophyllum ebulbum* King & Pantl., *B. ebulepharum* Reichb.f., *B. gamblei* (Hook.f.) Hook.f., *B. piluliferum*

King & Pantl., *B. sikkimensis* (King & Pantl.) J.J.Sm., *B. thomsonii* Hook.f., *B. cornu-cervi* King & Pantl, *Calanthe whiteana* King & Pantl, *C. chloroleuca* Lindl, *Cymbidium gammieanum* King & Pantl, *C. whiteae* King & Pantl, *Dendrobium clavatum* Roxb., *D. formosum* Roxb., *D. pegnuanum* King & Pantl, *D. sulcata* Lindl., *D. pauciflorum* King & Pantl, *D. terminale* Warner, *Eria connata* Joseph et al., *Gastrochilus arunachalensis* AN Rao, *G. intermedius*, *Rhododendron arboreum* Sm., *R. barbatum* G.Don, *R. grande* Wight, *R. hodgsonii* Hook.f., *R. falconeri* Hook.f., *R. nivale* Hook.f., *R. triflorum* Hook.f. and many more. In addition, *Corydalis cavei* D.G.Long, *C. changuensis* D.G.Long, *Hedychium gardenerianum*, *Juniperus recurva* Buch.-Ham. ex D.Don, *J. indica* Bertol., *Licuala peltata* Roxb. ex Buch.-Ham (Chinese fan palm), *Meconopsis bella* Prain, *Michelia champaca* L., *Paphiopedilum fairieanum* (Lindl.) Stein, *P. venustum* (Wall. ex Sims) Pfits, *P. wardii* Summerh., *Phalaenopsis lobbii* (Rchb.f.) Aver., *P. manni* Rchb.f., *P. parishii* Rchb.f., *Primula euosma* Craib, *P. ianthina* Balf.f. & Cave, *Renanthera imschootiana* Rolfe, *Rhynchostylis retusa* Blume, *Rosa macrophylla* Lindl., *R. sericea* Lindl., *Saxifraga coarctata* W.W. Smith, *S. exigua* H.Smith, *S. hookeri* Engl. ex Irmachi, *Viburnum cordifolium* Hook.f. & Thomson, and *Wallichia triandra* (Joseph) S.K.Basu are some other ornamental species.

Wild relatives of crop species

Actinidia strigosa Hook.f. & Thomson (wild relative of kiwi fruit), *Albizia kalkora*

Prain, *Allium wallichii* Kunth, *Amomum aromaticum* Roxb., *A. subulatum* Roxb., *Amorphophallus bulbifer* Blume, *Areca triandra* Roxb. ex Buch.-Ham., *Artocarpus chama* Buch.-Ham. (syn. *A. chaplasha* Roxb.), *Avena fatua* L. subsp. *glabrata* (Peterm.) Piper & Beattie, *Brassica trilocularis* Hook.f. & Thomson, *Cajanus elongatus* (Benth.) Maesen, *C. grandiflorus* (Benth. ex Bak.) Maesen, *C. mollis* (Benth.) Maesen, *C. scarabaeoides* (L.) Thouars, *C. villosus* (Benth. ex Baker) Maesen, *Camellia caudata* Wall., *C. drupifera* Lour., *C. irrawadiensis* Barua, *C. kissi* Wall., *C. siangensis* T.K.Paul & M.P.Nayar, *C. taliensis* Melchior, *Cinnamomum caudatum* Nees, *C. impressinervium* Meisn. Merssu., *C. obtusifolium* Nees (syn. *C. bejolghota* Buch.-Ham.), *Citrus aurantium* Linn., *Coffea benghalensis* Roxb., *C. khasiana* Hook.f., *Cucumis hystrix* Chakrav., *Curcuma amada* Roxb., *C. aromatica* Salisb., *C. caesia* Roxb., *C. montana* Roxb., *Digitaria cruciata* Nees, *Dioscorea bulbifera* L., *D. deltoidea* Wall., *D. hamiltonii* Hook.f., *D. hispida* Dennst., *D. pentaphylla* L., *D. prazeri* Prain & Burkill, *D. wallichii* Hook.f., *D. wattii* Prain & Burkill, *Duchesnea indica* (Andrews) Focke, *Eleusine indica* Steud. (wild relative of finger millet used for fermentation of the chiyang drink by the Lepchas), *Elymus tangutorum* (Nevski) Hand.-Mazz., *E. thoroldianus* (Oliver) G.Singh (wild relative of wheat), *Eriobotrya dubia* Decne., *E. hookeriana* Decne., *E. petiolata* Hook.f., *Fragaria vesca* Walter, *Garcinia hombroniana* Pierre, *G. xanthochymus* Hook.f., *Glycine soja* Siebold & Zucc.,

Hordeum agriocrithon Aberg Aberg, *Kaempferia sikkimensis* King ex Baker, *Lactuca cooperi* J. Anthony, *Lepidium capitatum* Hook.f. & Thomson, *Livistona jenkinsiana* Griff. (wild Chinese fan palm), *Luffa graveolens* Roxb., *Malus baccata* Loisel., *M. sikkimensis* (Wenzig) Balakr., *Mangifera khasiana* Pierre, *M. sylvatica* Roxb., *Miscanthus nepalensis* Hack., *Momordica macrophylla* Gage, *Musa mannii* H.Wendl. ex Baker, *M. acuminata* Colla, *M. balbisiana* Colla, *M. cheesmanii* N.W.Simmonds, *M. nagensium* Prain, *M. sikkimensis* Kurz, *M. velutina* H.Wendl. & Drude, *Myrica esculenta* Buch.-Ham. ex D.Don, *Neoluffa sikkimensis* Chakrav., *Oryza meyeriana* Baill., *O. minuta* J.Presl & C.Presl, *Phoenix acaulis* Roxb., *P. rupicola* T.Anderson, *Picea morinda* Link, *Pimpinella urceolata* Watt ex Banerji, *Piper clavilimbium* C.DC., *P. tilipedunculum* C.DC., *P. isopleurum* C.DC., *P. laxivenum* C.DC., *P. mungpooanum* C.DC., *P. ovatistigmum* C.DC., *P. sikkimense* C.DC., *P. sonadense* C.DC., *P. tenuitybracteatum* C.DC., *Polytoca wallichiana* (Nees) Beth., *Prunus acuminata* Hook.f., *P. arborea* (Blume) Kalkman, *P. bracteopadus* Koehne, *P. cornuta* Wall., *P. himalaica* Kitam., *P. imanishii* Kitam., *P. jenkinsii* Hook.f., *P. napaulensis* (Ser.) K.Koch, *P. rufa* Steud., *P. undulata* Buch.-Ham., *P. zippeliana* Miq., *Pyrus khasiana* Hook.f. (khasi pear), *P. pashia* Buch.-Ham. ex D.Don (wild pear), *P. serotina* Rehder, *Rhus griffithii* Hook.f., *Ribes acuminatum* Wall. & G.Don, *R. glaciale* Wall. (wild black currant), *Rubus ghankantus* Joseph et Rolla Rao, *R. hypargyrus* Edgew. var.

niveus (Wall. ex G.Don) H.Hara, *R. fragarioides* Bertol., *R. lineatus* Reinw. ex Blume, *R. moluccanus* Linn., *R. niveus* Thunb. var. *micranthus* (D.Don) Hara, *R. reticulatus* Wall. ex Hook.f., *R. senchalensis* Hara, *R. sikkimensis* Kuntze ex Hook.f., *R. wardii* Merr., *Saccharum longisetosum* Nayaran. ex Bor, *S. ravennae* Murr., *S. sikkimensis* Hook.f., *S. williamsii* (Bor) Bor ex Cope, *Solanum bracteatum* Thunb., *S. kurzii* Brace ex Prain, *S. spirale* Roxb., *Sorbus vestita* Lodd., *Trichosanthes cordata* Wall., *T. tricuspidata* Lour., *T. wallichiana* Wight, *Triticum polonicum* L., *Tsuga dumosa* Eichl., *Vigna clarkei* Prain, *Vitis heyneana* Wall., *V. himalayana* Brandis, *V. lanata* Roxb., *V. latifolia* Vahl ex Steud., *V. parviflora* Bak., *Zingiber capitatum*, *Z. chrysanthum* Rosc., *Z. clarkei* King ex Baker, *Z. zerumbet* (L.) Sm. (Arora and Nayar, 1984; Nayar, 1996).

Endemic species

Acer hookeri Miq. var. *majus* Pax, *A. oblongum* Wall. ex DC., *A. sikkimense* Miq. var. *serrulatum* Pax, *Aconitum lethale* Griff., *Albizia arunachalensis* K.C.Sahni & H.B.Naithani, *Argyreia sikkimensis* (C.B.Clarke) van Ooststr., *Biermannia jainiana* S.N.Hegde & A.N.Rao, *Bulbophyllum obrienianum* Rolfe, *Boehmeria tirapensis* Deb et Dutta, *Camellia siangensis* T.K.Paul & M.P.Nayar, *Capparis pachyphylla* M.Jacobs, *Chimonocalamus longispiculatus* (C.S.Chao & Renvoize) Ohrnb., *Cleisostoma tricallosum* S.N.Hegde & A.N.Rao, *Desmodium kulhaitense* C.B.Clarke ex Prain, *D.*

dioicum DC., *D. likabaliu*m Bennet & Chandra, *Diplomeris josephii* A.N.Rao & M.S.Swaminathan, *Elaeocarpus dubius* Aug.DC. (wild *rudraksh*), *Hopea shingkeng* (Dunn) Bor, *Lactuca cooperi* J.Anthony, *Lithocarpus kamengii* Sahni & Naithani, *Oberonia auriculata* King & Pantl., *Pholidota convallariae* Hook.f. var. *brevicapsa* Deori & Joseph, *Pimpinella tangolensis* P.K. Mukh., *Piper filipedunculum* C.DC., *P. isopleurum* C.DC., *P. laxivenum* C.DC., *P. mungpooanum* C.DC., *P. sikkimense* C.DC., *Podophyllum emodii* Wall ex Honigberger var. *axillaris* Chatterjee & Mukerjee, *Rhododendron concinnoides* Hutch. & Ward, *R. falconeri* Hook.f. subsp. *exiimium*, *R. santapau*i Sastry, Katakai, Peter Cox, Patricia Cox & P.Hutchison, *Rubus ghankantus* Joseph et Rolla Rao, *R. niveus* Wall. var. *micranthus*, *R. senchalensis* Hara, *Salix pseudocalyculata* A.Kimura, *S. stomatophora* Floderus, *Saussurea andersonii* C.B.Clarke, *S. forrestii* Diels, *S. gossypiphora* Wall. var. *liliputa*, *S. laneana* W.W.Sm., *S. nimborum* W.W.Sm., *S. obscura* Lipsch., *Wallichia triandra* (Joseph) S.K. Basu (Nayar, 1996), and many more orchids from Sikkim (<http://www.envis.nic.in/soer/soer-skkim/orchids.html>). Table 1 lists some of the economic plant species endemic to the region.

Threatened economic species

Acer hookeri Miq. var. *majus* Pax, *A. osmastonii* Gamble, *A. sikkimense* Miq. var. *serrulatum* Pax, *Capparis pachyphylla* Jacobs, *Cinnamomum glanduliferum*

Table 1. Representative agriculturally important species endemic to the Probable Agricultural Biodiversity Heritage Site (Eastern Himalayan Region: Arunachal Pradesh, Sikkim, and the hills of West Bengal).

Species	Family	Habit	Distribution	Use
<i>Acer oblongum</i> var. <i>microcarpum</i>	Aceraceae	Evergreen tree	Mishmi hills	15–18 m tall, hardwood used for making agricultural implements, and leaves for packing apples
<i>Aconitum lethale</i>	Ranunculaceae	Herb	Mishmi hills	Medicinal, used as 'vish' (poison) by the Mishmi tribes
<i>Aerides rosea</i>	Orchidaceae	Herb	Eastern Himalayas	Showy orchid
<i>Agrostophyllum myrianthum</i>	Orchidaceae	Herb	Sikkim	Ornamental orchid
<i>Albizia arunachalensis</i>	Fabaceae	Tree	Arunachal Pradesh	Wood, wild relative
<i>Anthogonium gracile</i>	Orchidaceae	Herb	Sikkim	Ornamental orchid
<i>Aphylorchis alpina</i>	Orchidaceae	Herb	Sikkim	Ornamental orchid
<i>Argyreia sikkimensis</i>	Convolvulaceae	Climber	Sikkim	Medicinal spice
<i>Biermannia jainiana</i>	Orchidaceae	Herb	Arunachal Pradesh	Ornamental orchid
<i>Bulbophyllum obrienianum</i>	Orchidaceae	Herb	Arunachal Pradesh	Ornamental orchid
<i>Chimonocalamus longispiculatus</i>	Bambusoideae	Shrub	Arunachal Pradesh	Tall, woody bamboo for cane
<i>Cleisostoma tricallosum</i>	Orchidaceae	Herb	Arunachal Pradesh	Ornamental orchid
<i>Desmodium kulhaitense</i>	Fabaceae	Subshrub	Sikkim	Forage
<i>Diplomeris josephii</i>	Orchidaceae	Herb	Arunachal Pradesh	Ornamental orchid
<i>Epipogium sessanum</i>	Orchidaceae	Herb	Arunachal Pradesh	Ornamental orchid
<i>Eria connata</i>	Orchidaceae	Herb	Arunachal Pradesh	Ornamental orchid
<i>Eria jengingensis</i>	Orchidaceae	Herb	Arunachal Pradesh	Ornamental orchid

continued

Table 1. *continued*

Species	Family	Habit	Distribution	Use
<i>Gastrodia arunachalensis</i>	Orchidaceae	Shrub	Arunachal Pradesh	Ornamental
<i>Hopea shingkeng</i>	Diterocarpaceae	Tree	Abor hills	16–18 m tall, medicinal, and used for construction of posts
<i>Oberonia sulcata</i>	Orchidaceae		Arunachal Pradesh	Ornamental orchid
<i>Pholidata convallariae</i> var. <i>brevicapsa</i>	Orchidaceae		Arunachal Pradesh	Ornamental orchid
<i>Podophyllum emodii</i> var. <i>axillaris</i>	Podophyllaceae	Herb	Sikkim Himalaya	Medicinal: hepatic stimulant, cholagogue, and alternative, emetic and purgative
<i>Rhododendron concinnoides</i>	Ericaceae	Shrub	Arunachal Pradesh	Multipurpose (ornamental, medicinal)
<i>Rhododendron falconeri</i> subsp. <i>exiimium</i>	Ericaceae	Tree	Arunachal Pradesh	Multipurpose (ornamental, medicinal)
<i>Rhododendron santapaui</i>	Ericaceae	Epiphytic shrub	2,300 m	Multipurpose (ornamental, medicinal)
<i>Rhododendron subansirensis</i>	Ericaceae	Large shrub	2,600–3,400 m	Multipurpose (ornamental, medicinal)
<i>Wallichia triandra</i>	Arecaceae	Bushy plant	Arunachal Pradesh	Multipurpose, rare palm
<i>Zeuxine lindleyana</i>	Orchidaceae	Herb	Arunachal Pradesh	Ornamental orchid

Mesin., *Cotoneaster simonsii* Hort. ex Baker, *Dendrobium aurantiacum* Rchb.f., *D. pauciflorum* King & Pantling, *Dioscorea deltoidea* King & Prain ex King & Pantling, *Lactuca cooperi* Anthony, *Livistona jenkinsiana* Griff., *Nardostachys grandiflora* DC., *Panax pseudo-ginseng*

Wall., *Phoenix rupicola* T. And., *Picea spinulosa* (Griff.) Henry, *Picrorhiza kurroa* Royle ex Benth., *Rhododendron concinnoides* Hutch. & Ward, *R. dalhousiae* Hook.f. var. *rhabdotum* (Balf.f. & Cooper) Cullen, *R. formosum* Wall., *R. santapaui* Sastry *et al.*, *Vanda coerulea* Griff. ex Lindl.

(orchid), *Wallichia triandra* (Joseph S.K. Basu (palm) (Nayar, 1996). Table 2 lists some of the economic plant species under threat.

Associated culture and tribes

Agriculture is the main occupation of the region, contributing the maximum to the state treasuries. The region is predominantly inhabited by Mongoloids with the influence of Tibetan culture. The original inhabitants of Sikkim are said to be the Lepchas. The earliest Lepcha settlers were believers in the

bone or *mune* faith. This faith was basically based on spirits, good and bad. They worshiped the spirits of the mountains, rivers, and forests, which was but natural for a tribe that co-existed so harmoniously with the rich natural surroundings. Therefore, the very cultural fabric of Sikkim's society is predominantly dependent on conservation of the entire sacred landscape. The uniqueness of this heritage lies in the holism and interaction between soil, water, biota, visible water bodies, rivers, and lakes, all taken together, including physical monuments, such as monasteries. A variety of traditional agricultural systems

Table 2. Representative agriculturally important species under threat in the Probable Agricultural Biodiversity Heritage Site (Eastern Himalayan Region: Arunachal Pradesh, Sikkim, and the hills of West Bengal).

Species	Family	Habit	Threat level ¹	Use
<i>Acer sikkimense</i> var. <i>serrulatum</i>	Aceraceae	Tree	EN	Wood
<i>Cajanus sericeus</i>	Fabaceae	Shrub	I	Wild relative of pigeonpea
<i>Cinnamomum glanduliferum</i>	Lauraceae	Tree	I	Yields camphor
<i>Dendrobium aurantiacum</i>	Orchidaceae	Herb	VU	Epiphyte, ornamental
<i>Gastrodia arunachalensis</i>	Orchidaceae	Shrub	EN	Ornamental orchid
<i>Lactuca cooperi</i>	Asteraceae	Herb	EN	Forage, wild relative
<i>Phoenix rupicola</i>	Arecaceae	Tree	CR	Farinaceous pith edible
<i>Rhododendron concinnoides</i>	Ericaceae	Shrub	EN	Multipurpose (ornamental and medicinal)
<i>Rhododendron formosum</i>	Ericaceae	Shrub	VU	Multipurpose (ornamental and medicinal)
<i>Rhododendron santapau</i>	Ericaceae	Shrub, sometimes epiphytic	EN	Multipurpose (ornamental and medicinal)
<i>Vanda coerulea</i>	Orchidaceae	Epiphytic herb	CR	Ornamental orchid
<i>Wallichia triandra</i>	Arecaceae	Palm	R	Ornamental palm

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

The original inhabitants of Sikkim are said to be the Lepchas. The earliest Lepcha settlers were believers in the bone or mune faith. This faith was basically based on spirits, good and bad. They worshiped the spirits of the mountains, rivers, and forests, which was but natural for a tribe that co-existed so harmoniously with the rich natural surroundings.

interlinked with nomadism of some of the tribes like the Bhutias makes this a very interesting and unique system/site.

In Arunachal Pradesh, 63% of the total population belongs to 19 major tribes and 85 minor tribes. Most of them are either of Tibeto-Burman or Tai-Burmese origin. Another 35% of the population is made up of immigrants, from adjacent states of the northeast region and other parts of India, which has made a considerable impact on the local people. The largest major tribes include the Adi, Galo, Nishi, Khamti, Monpa, Apatani, and Hill Miris (Gangwar and Ramakrishnan, 1989). These tribes are heavily dependent on local bioresources. As per one estimate, 171 plant species are used by the Nishis, the Hill Miris, the Sulungs, and the Apatanis of the Lower Subansiri district of Arunachal Pradesh, and 12 animal species by the Nishis. Of the total plant species recorded, 38% were leafy vegetables and 28% were edible fruits. Other species were used for food, liquor, medicine, household goods, traditional dresses, dyes, tattoos, fish and animal poisons, or for salt extraction. The Sulungs use starch

obtained from the pith of *Metroxylon sagu* and eat it as a staple food. The extensive use of wild plants and animals suggests that the tribes of northeastern India relied heavily on forest resources and over time have developed significant knowledge on their potential value.

Among the transhumant Monpa pastoralists of the alpine terrain of Tawang, Arunachal Pradesh, the yak herders who are indigenous to the area own some cattle, mules, horses, and sheep, and practice limited horticulture on their village lands, at around 3,000 m. To feed such a large stock of yaks, they practice nomadism. While the Monpa men take their herds over long distances in search of pasture, the women, children, and the elderly remain in the villages throughout the year, tending the remainder of their livestock and collecting firewood. For sustainable grazing, they traditionally rotate between a multi-pasture encampment used in mid- and late-winter, spring, and summer with an encampment used in autumn and early winter. This system allows them to utilize a series of common grazing lands, while providing an ample supply of un-grazed forage reserves for use in autumn and early winter on which the animals subsist through the long winters. This environment-friendly approach has sustained the pastoral economy and has become the basis of Monpa pastoralist identity (Duarah, 1992). Until quite recently, Monpa pastoralists, who are Mahayana Buddhists (Sarkar, 1980) were following a unique polyandrous system as per the demand of the situation. Since herds are owned jointly by brothers and both livestock rearing through nomadism and upbringing of the family have to be carried

out, one herder is replaced by his brother, after a while, in exchange of responsibilities. However, with time, such systems are changing.

Technology and products

Jhum, the traditional farming system, which involves shifting cultivation after clearing of forest lands, has led to severe soil erosion. The extreme climatic conditions, particularly in high-altitude areas, have restricted the choice of crops. However, the indigenous people have developed methods for soil conservation, effective use of water resources and for the creation of terraces on hill slopes. In this improved system, the common cultivation of rice and millets on terraces dominates.

The wet rice cultivation developed by the Apatanis of Arunachal Pradesh is considered to be a highly evolved valley cultivation system of rice, perfected over centuries with effective water and energy use efficiency and conservation of soil fertility. This village ecosystem is a good example of economic self-sufficiency of a traditional agricultural society that practices ecologically sedentary agriculture.

The region is very rich in species diversity, consequent to which it has the maximum number of wild relatives of crop species (see list of wild relatives of crop species) making the region a reservoir of genes. Similarly, high crop diversity has evolved valuable genetic resources in a number of crop species for allele mining. In rice genetic resources, Arunachal Pradesh is known for desirable genetic variability for short stature, short duration, stem borer

resistance, and low amylase content (*japonica*; from Kamang) type (Siddiq *et al.*, 2006). In wheat, the Sikkim region is known for variability in the spike-awn ratio, grain color, and grain shriveling (Singh *et al.*, 2006). The Northeastern Himalayan region, because of occurrence of the multi-cob primitive type of maize, led to a proposition of maize being of Asiatic origin. These were described as the Sikkim primitive types (Singh, 1977). Singh described 15 landraces, of which some important ones are Anantnagar, Bassi, Chamba, Sikkim, Sathi, Samri, etc. These landraces have been used in breeding programs to increase the number of cobs per plant, exploiting their multiple-cob trait.

In oilseeds, variability has been recorded in soybean, among the local black-seeded landraces. The wild relative *Glycine soja* occurring in the region has been identified as a source of resistance to leaf yellow mosaic virus, and is being used in the national breeding program on a regular basis. Useful variability has been reported in niger for cold tolerance. Large genetic diversity has been recorded in *Saccharum spontaneum* L. and species of the related genus *Erianthus arundinaceus* Retz.; the two have desirable variability for cold tolerance, diseases, and yield. The natural hybrid between these two species has further released variability for desirable traits (Sreenivasan and Amalraj, 2004).

In horticulture crops, the region is in continuum of variability recorded for the Himalayan region, and shares some of the national variability in the case of potato, with the variety Darjeeling Red Round. In

addition, the region has been recorded to have variability in okra for fruit and plant types, and has wild relatives of crop species such as *Luffa graveolens* (Sirohi *et al.*, 2005). Sikkim grows a special chili locally known as ‘*Dalle Khorsani*’ with good aroma and considerable pungency.

The region is known for cultivation of certain temperate fruits, but the level of variability is low. Wild kiwi (*Actinidia callosa* Lindl. and *A. strigosa*) is found growing in the natural forests of Arunachal Pradesh and Sikkim. However, the region is very rich in genetic diversity of certain tropical fruits, particularly *Citrus*, which extends to the Northeast Hill region. Mandarin (*Citrus reticulata*) is well represented in Sikkim. Some native *Mangifera* spp., such as the wild form of *M. indica* L. and its allied species *M. sylvatica*, occur in Arunachal Pradesh. Among spices, the region is known for variability in *Piper nigrum*, cardamom, large cardamom, ginger, and turmeric. Sikkim is known for cultivation and variability in large cardamom, besides tea and coffee, and also for crisp ginger with high moisture content, while Arunachal Pradesh is known for turmeric.

Among the transhumant Monpa pastoralists of the alpine terrain of Tawang, Arunachal Pradesh, the yak herders who are indigenous to the area own some cattle, mules, horses, and sheep, and practice limited horticulture on their village lands, at around 3,000 m. To feed such a large stock of yaks, they practice nomadism.

The local people of the region have developed important information about the medicinal value of local plants and have been using them regularly in health care. For example, the Chakma community in Arunachal Pradesh use *Achyranthes aspera* L. against urinary disorders; *Catharanthus roseus* (L.) G.Don, known as an anti-cancer drug, is being used against diabetes; and *Centella asiatica* (L.) Urban is used against stomach disorders by different tribes. Orchids as medicinal agents have also been used by the tribes of Arunachal Pradesh.

Future perspective

The region’s typical problems – sloping terrain, inaccessibility of most agricultural zones, depletion of forest natural resources, water scarcity during the lean period and heavy rainfall during the monsoon and consequent soil erosion – need to be tackled with scientific research input. Therefore, greater research efforts are needed to strengthen the scientific capabilities of the youth of the region. Traditional orange cultivation has been hit by the dieback disease; rejuvenation programs and the introduction of resistant root stock would greatly help in reviving this important crop.

The species diversity available among edible plant species, belonging to both field and horticulture, particularly in species with floriculture potential, offers rare opportunities for economic exploitation through domestication. For example, *Phaseolus coccineus* from Sikkim can be

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used as a nutritious grain legume, while ornamental species such as orchids and rhododendron, which have been protected by the local communities for centuries, can be exploited for promotion of floriculture and other uses, to increase local farmers' income. Sikkim is the natural home for about 475 species of orchids found in various climatic conditions from warm to humid hills, to snow peaks. Therefore, the agroclimatic condition of Sikkim offers successful cultivation of diverse varieties of orchids as well as temperate flowers such as lily, anthurium, carnation, gerbera, glaxonia, gladiolus, begonia, ornamental foliage, ferns and a host of other flowering species. Rhododendrons offer added opportunities for multipurpose exploitation (ornamental, spice, medicinal), with bright perspectives for increasing farmers' incomes and good professional alternative. In addition, the temperate hilly conditions offer a good scope for seed production of various temperate vegetables such as broccoli, cabbage, cauliflower, beans, peas, onion, true seed of potato, etc., in collaboration with private companies having expertise in seed production. Additionally, most crops in the region are grown in more or less organic conditions. This can be popularized as additional value

to the products marketed from the region, whether it is commercial cardamom and ginger, or exquisite orchids or mandarin orange, cherry, pepper, and other field produce.

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