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Probable Agricultural Biodiversity Heritage Sites in India: VI. The Northeastern Hills of Nagaland, Manipur, Mizoram, and Tripura

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Abstract

The Northeastern Hill region of India, comprising Nagaland, Manipur, Mizoram, Tripura, and parts of the Cachar district of Assam, has been proposed as another National Agricultural Biodiversity Heritage Site, due to its location in the lowland–highland transitional zone, richness in species and crop genetic diversity, diverse topography with a hilly-sloping terrain, and the prevalence of traditional shifting and bun *cultivation. To circumvent the difficulties of the hilly terrain, the local communities have developed unique indigenous farming systems such as* zabo*, alder, and swidden, based on local resources, which facilitate conservation as well as effective and efficient use of natural resources. Over time, the systems have been further improved with systems, such as terrace-*panikheti*. The region is inhabited by a number of tribes, evolved from diverse racial stocks, such as Mongoloids, Indo-Mongoloids, and Austrics, with the influence of Aryan culture and both Hindu and Christian religions, evolving a complex culture. The local communities have conserved a large number of species in their* baris *(backyard gardens), and in the process of cultivation, the environmental and human selection pressures have helped evolve useful genetic diversity in important crops. Consequently, the region has made a significant contribution to international agriculture by making available landraces, such as* 'Latisail'*, which has contributed its germplasm to 80% of the semi-dwarf rice varieties cultivated in Asia. The article discusses these facts in depth to justify the propostion as per the indices for identification and assessment of agrobiodiversity heritage sites.*

The physiography divides the northeastern region of India into three divisions: the Meghalaya plateau, the Northeastern Hills, and the Brahmaputra Valley. The Northeastern Hills account for 65% of the total land area. This region is unique, being part of the area where the land mass of the southern hemisphere met with that of the northern hemisphere, formulating the transition zone of lowland–highland with the

highest diversity of biomes and ecological communities, where the species diversities within these communities is extremely high. The region constitutes a geographical 'gateway' for much of India's flora and fauna, consequent to which, the region is one of the richest in biological values. The region is also bestowed with rich natural resources of soil, water, and climate.

The northeastern region is characterized by unique but difficult hilly terrain, undulating topography with prevalence of primitive forms of food production systems – shifting cultivation and *bun* cultivation. Shifting cultivation is still practiced, despite its contribution to accelerated soil erosion and runoff from the agricultural fields. However, the farmers of certain localities have adapted indigenous technical knowledge to facilitate conservation of soil and water, and to enhance soil productivity. The *zabo* system, the alder system, and rice cultivation in terraces-*panikheti* in Nagaland are some of the examples of excellent application of indigenous technical knowledge for resource conservation and effective use. Additionally, puddling of the bottom of the water harvesting ponds in the catchment areas, followed by plastering the bottom and sides of the pond with a paste of clay, rice husk, and cow dung, to help water conservation, are some other ingenious technologies evolved by local farmers, while interacting with the hilly and sloping landscape. These time-tested systems were developed by the local tribal farmers using their ingenuity and skill based on their long experience of generations, under the prevailing soil, climate, and remote situations of the region. The use of locally available materials and organic sources of nutrients make these systems sustainable. Therefore, this region can be considered as a co-inventor of the shifting cultivation (*jhum*) system along with Meghalaya hills, with suitable improvisation reconciling with the landscape, to facilitate conservation of bioresources. Unfortunately, this traditional knowledge has remained confined to their place of origin and has not spread further. Moreover, the economic constraints and some biophysical limitations have confined the agriculture mostly to a subsistence level. Nevertheless, the region, because of these technological innovations and diverse ecologies, has been able to cultivate a large number of crop species, particularly in horticultural crops, and evolve a wide spectrum of genetic variability.

In addition to being one of the most enriched regions in terms of its flora and fauna, and technology, the region has a distinct culture and is home to various indigenous tribal communities belonging to the Austro-Asiatic linguistic family. This complex culture has influenced the locals both socially and agriculturally. For example, the Nepalese alder is a socially valued species with nitrogen fixing capacity, conserved by traditional societies of this region with its integration in their shifting agriculture plots. Therefore, it is a social 'keystone' species. The swidden farming system adopted by the Angami tribal community of Nagaland, involving cultivation of 15 to 30 crop species in the same plot of land after *jhum* forest clearing, is a unique method practiced by the women of the region to facilitate the conservation of agrobiodiversity. In the olden days, hunting/trapping was practiced with considerable prudence and had many taboos

and restrictions. For example, the Anaal Naga in Manipur did not consume turtle or tortoise meat. The Maram Naga did not eat pork, and the Thangkhul Naga did not eat any member of the cat family. This facilitated the conservation of these species and the maintenance of the ecological balance. Unfortunately, such taboos do not hold any sway among the people now.

Therefore, the Northeastern Hill region of Nagaland, Manipur, Mizoram, and Tripura – given its rich species and crop genetic diversity, unique and effective technologies for sustainable and integrated bioresource conservation and use, including unique composite irrigation and fertilization systems – deserves to be designated as another National Agricultural Biodiversity Heritage site based on the criteria suggested by Singh and Varaprasad (2008). Many other facts are worth a mention to support justification:

- Nagaland has an agrarian economy with over 70% of the population dependent on agriculture, and maintains a rich genetic diversity in crops such as rice, millet, maize, pulses, sugarcane, potato, coffee, cardamom, tea, etc.
- Manipur has rich genetic diversity in crops such as paddy, wheat, maize, pulses, oilseeds, and rubber, and occupies a unique position among Indian handicrafts (including cane and bamboo crafts).
- Mizoram has a rich and unique bamboo genetic diversity (covering 12,544 sq km of the state), contributing to 14% of the national bamboo production.
- Tripura is the second largest producer of rubber in the country (265 km^2 of the state is under rubber).

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Location and extent

This agricultural biodiversity heritage site includes the northeastern hilly states of Nagaland, Manipur, Mizoram, and Tripura, and the adjoining districts of Cachar and North Cachar of Assam (Fig. 1). The state

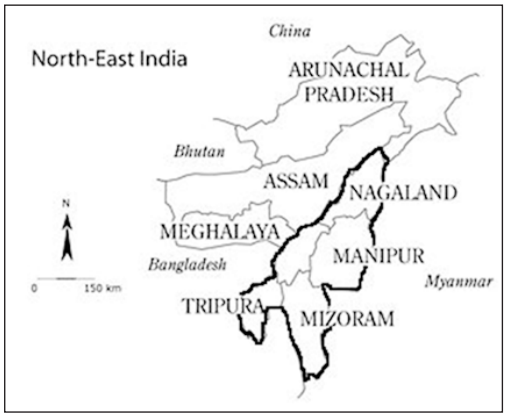

Figure 1. Location and extent of the Northeastern Hill Region.

of Nagaland extends between 25°05' and 27°10' N latitude, and 93°28' and 95°05' E longitude. The hills of Nagaland are in parallel folds running from north to south. The Saramati Peak (3,841 m) is the highest. The state of Manipur lies to the south of Nagaland, and in continuation extends between 23°50' and 25°41' N latitude, and 92°59' to 94°47' E longitude. Manipur has a hilly terrain ranging from 850 m to 3,000 m, with folds of mountains running in the same north to south direction, in continuation of the Patkoi and Naga hills. Mizoram is located further down, between 21°58' and 24°35' N latitude, and 92°16' and 93°29' E longitude. It has international borders with Myanmar on the east and south, and with Bangladesh on the west. Manipur lies to its north and Tripura to its west. The mountain ranges again run parallel in continuation, from north to south. The Phawngpui mountain, rising up to 2,165 m, is called the Blue Mountain of Mizoram. Tripura is bordered by Bangladesh on three sides, whereas Mizoram and Assam lie on the eastern side. The state is located between 22°56' and 24°32' N latitude, and 91°10' and 92°21' E longitude.

Landscape

The landscape of the region is dominated by the diverse range of hills, valleys, gorges, lakes, and a network of streams and rivers running across the states, supporting rich biodiversity in the form of forests. Nagaland is a hilly state with high mountains, deep gorges, lush valleys, and winding streams. The dominant geographic feature of the landscape is the Naga Hills, which run all the way through the state and contribute to the mountainous terrain. Manipur boasts of an exotic landscape with gently undulating hills, emerald-green valleys, blue lakes, and dense forests. Mizoram too is a land of hills, which run in ridges from north to south. They have an average height of 900 m, the highest point being the Phawngpui, the Blue Mountain (2,165 m). The Tropic of Cancer passes near the capital, Aizawl. There are a number of rivers in Mizoram. The important ones in the northern part of the state are the Tlawng (Dhaleshwari), the Tuirial (Sonai), and the Tuivwal, which flow northwards and fall in the Barak River in the Cachar district of Assam. These three rivers are navigable. In the southern part of Mizoram, the Chhimtuipui (Kolodyne) is an important river having four tributaries – the Mat, the Tuichang, the Tyao, and the Tuipui.

In addition to being one of the most enriched regions in terms of its flora and fauna, and technology, the region has a distinct culture and is home to various indigenous tribal communities belonging to the Austro-Asiatic linguistic family.

Geographically, Manipur can be divided into two parts – the Imphal Valley and the surrounding hills. The Imphal Valley is full of small lakes and swamps. The hills, termed as sub-Himalayan ranges, are covered with rich forest cover that includes rubber, tan, oak, ash, teak, and palm. Many different varieties of bamboo are also found all over Manipur. Eeril and Thobal are the two big rivers of Manipur that originate from the hills and flow down into the valley. The Blue Hills surrounding the valley and covering the rest of the state give an enchanting look to

the landscape. Most of the land in Manipur is barren and considered uncultivable. Tripura is a landlocked hilly state with altitudes varying from 15 to 940 m above sea level. The state is covered by picturesque hills and dales, deep and green valleys, which add to the beauty.

While the landscape in the other states is dominated by lofty mist-clad hills, Tripura has rolling verdant valleys. The principal hill ranges are the Jampoi, Sakham Tlang, Langtarai, Athara Mura, and Bara Mura. The highest peak of the state is Be-talang-Shiv (975 m) in the Jampoi hill range. A number of broad and elongated valleys – Agartala, Udaipur, Sabrum, Khowai, Teliamura, Amarpur, Silachari, etc. – are located between the north-south trending, parallel to sub-parallel high ranges (topographic highs), such as the Baramura, Deotamura ranges, Atharamura ranges, Langtari ranges, Sakham ranges, and the Jampui hill ranges. The Khowati, Manu, Haorah, Muhuri, and the Gomati are some important rivers of Tripura.

Agroclimate

As in Meghalaya, the Northeastern Hill region is a warm perhumid ecoregion with red and lateritic soil. The climate of the region in general is characterized by warm summers and cold winters. During the winter months (October–February), the temperatures range between 4ºC and 24ºC; the summer months (March–June) take the temperatures up to 16–31ºC. Filling the gap between those months, the monsoon season sees heavy rains and the weather becomes slightly cooler than in the summer. The mean annual precipitation of the region varies from 1,600 to 2,600 mm, while potential evapotranspiration (PET) is 1,400–1,600 mm, leading to a moist perhumid moisture regime for most of the year. The hill regions of Manipur, Tripura, and Mizoram receive heavy rainfall (more than 2,000 mm) and the climate is extremely humid. The length of the growing season with availability of moisture exceeds 270 days. The short water deficit occurs during the postrainy season, causing seasonal dry spells. The major soil of the region includes shallow to very deep, loamy, red and lateritic, and red yellow soils. They are highly acidic in reaction and have moderate bases (Sehgal *et al.*,1992).

The landscape of the region is dominated by the diverse range of hills, valleys, gorges, lakes, and a network of streams and rivers running across the states, supporting rich biodiversity in the form of forests.

Tripura has a tropical climate. The climate of this state is generally hot and humid. The average maximum temperature is 35ºC in May–June, and the average minimum temperature is 10.5ºC in December–January. The average annual rainfall is

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around 2,300 mm. The monsoon starts generally in April and continues up to September. Summer starts in March and continues up to May, and is followed by the rainy season extending over about three–four months (May–August). The pleasant season lasts only for about two months (September–October). It is then followed by winter, which continues up to February. In Tripura, the soil in the valley is fertile with rich alluvial deposits, and therefore suitable for the cultivation of paddy, jute, oilseeds, pulses, fruits, and vegetables. About 54.5% of the land is under forest.

Floristic diversity

Northeastern India consists of two biodiversity hotspots (Mittermeier *et al*., 2004): the Himalaya and the Indo-Burma. The Northeastern Hill region, comprising Nagaland, Manipur, Mizoram, and Tripura, is part of the Indo-Burma hotspot, which has a wide variety of ecosystems, including hilly tracts. The Indo-Burma biodiversity hotspot comprises around 7,000 endemic plant species. Around 8,550 floral species have been recorded from this region, of which 2,500 are from Manipur, 2,250 from Nagaland, 2,200 from Mizoram, and 1,600 from Tripura.

The natural vegetation comprises evergreen and tropical moist deciduous forests. The forest types are: (1) **Tropical evergreen and semi-evergreen forests** with dominant species, *Castanopsis indica* (Roxb. ex Lindl.) A. DC. (= *Castanea indica* Roxb.), *Bischofia javanica* Blume, *Terminalia citrina* Roxb. ex Flem., *T. arjuna* (Roxb. ex DC.) Wight & Arn., *Artocarpus heterophyllus* Lam., *A. chama* Buch.-Ham., *Elaeocarpus floribundus* Blume, *E. rugosus* Roxb., *Polyalthia cerasoides* (Roxb.) Hook.f. & Thomson, *Dipterocarpus turbinatus* C.F.Gaertn., *D. macrocarpus* Vesque, *Amoora wallichii* King., etc.; (2) **Tropical moist and dry deciduous forest** with dominant species, *Albizia procera* Benth., *Anthocephalus chinensis* Hassk., *Sterculia villosa* Roxb., *Tectona grandis* L.f., *Shorea robusta* C.F.Gaertn., *Artocarpus chaplasha* Roxb., etc.; (3) **Temperate forest** with *Lithocarpus fenestratus* Rehder, *Quercus griffithii* Hook.f. & Thomson ex Miq., *Schima wallichii* Choisy, *Betula alnoides* Buch.-Ham., *Michelia doltsopa* Buch.-Ham. ex DC., *Castanopsis hystrix* A. DC., *Pinus kesiya* Royle ex Gordon., etc.; (4) **Bamboo forest** with *Bambusa tulda* Roxb., *B. pallida* Munro, *Melocanna baccifera* Skeels, *Dendrocalamus hamiltonii* Nees & Arn. ex Munro., etc.; (5) **Subalpine forest** with *Berberis micropetala* T.S.Ying, *B. manipurensis* (Takeda) Laferr., *B. wardii* C.K.Schneid., *B. sublevis* W.W.Sm., *Rhododendron wattii* Cowan, *Aconitum elwesii* Stapf, *Spiraea callosa* Thunb., etc.

Geographically, Manipur can be divided into two parts – the Imphal Valley and the surrounding hills.

Mizoram has the second highest forest cover (62%) of the region. It is a land of unending natural beauty with a variety of flora and fauna. The word “Mizo” means highlander. The state is a storehouse of exotic flora and fauna. The hills here can be seen covered with bamboo and banana

trees along with a wonderful array of pine trees. The forests also house some of the rare varieties of orchids that are found only in this region of the country. In Manipur, the forest area is sharply declining. The cropped area in Manipur and Nagaland is 8.32% and 12.40% respectively. While in Tripura, only about 24.3% of the area is available for agricultural use.

Agriculture and agrobiodiversity

Agriculture is the main occupation and the main source of income and revenue for the region. The traditional farming system is *jhum* (shifting cultivation). In addition, the tribal communities widely practice terrace cultivation. According to Ramakrishnan (1992), a typical *jhum* system is a mixed cropping system where seeds of all the crops that require planting are mixed at the seed stage and broadcast in the field during the first rainy days of the season on the land prepared after burning the forest land. Maize and rice seeds are dribbled in furrows at regular intervals. Tuber crops such as aroids, ginger, and tapioca, and banana are planted or sown throughout the growing season. The castor plant (*Ricinus communis* L.) is planted along the borders for rearing silkworms. The crops are routinely harvested at different seasons and they are replaced by other seasonal crops [*Ipomoea batatas* (L.) Poir., *Eleusine coracana* Gaertn., *Dioscorea alata* L., *Coix lacryma-jobi* L.] at regular intervals. This traditional *jhum* cultivation is followed by most subsistence farmers.

Tripura has a tropical climate. The climate of this state is generally hot and humid.

Terrace cultivation is widely practiced by the tribal communities. The major crops include rice, maize, millets, pea, oilseeds (rapeseed/mustard and niger), fibers, sugarcane, tobacco, potato, etc. The farmers also cultivate a variety of temperate, subtropical, and tropical vegetables, which includes pea, carrot, chili, onion, melon, spinach, cucumber, brinjal (eggplant), tomato, Brassicas, yam, and arums in home garden as well as in terraced field. They may be a monocrop or in mixed cropping system with diverse ingredients. The important cropping systems are rice–mustard, rice–pea, maize–mustard, niger–mustard.

Because of diversities in topography, altitude, and climatic conditions, the region offers a great scope for cultivation of a wide variety of horticultural crops, such as fruits, vegetables, tuber and rhizomatous crops, spices, flowers, and medicinal plants of temperate, subtropical and tropical nature. Commercially, temperate, subtropical, and tropical fruits and vegetables, both indigenous and exotic, are doing well in this region. Commercial cultivation of temperate fruits such as plum, peach, and pear are seen in the higher elevations of Mizoram, Manipur, and Nagaland. Other promising temperate fruits, such as walnut, almond, and cashewnut are grown in Tripura. The plain and valley land of Tripura and Manipur are suitable for most of the tropical and subtropical fruits, such as banana, pineapple, citrus, coconut, mango, jackfruit, papaya, litchi, guava, etc. However, banana,

pineapple, citrus, papaya, plum, peach, apple, etc. are widely grown in the hills of Mizoram, Manipur, and Nagaland. The cultivation of pineapple is concentrated in Manipur. Among *Citrus*, commercial cultivars of mandarin orange and lemon are being grown. Arecanut, betel-vine, and several spice crops are grown throughout the region. In addition to tea, coffee, cardamom, coconut, arecanut, and rubber are the plantation crops grown mainly in Tripura (Fig. 2). Enormous variations of crops as well as practices of growing vegetables can be seen both in the *kharif* and *rabi* seasons in the region.

One of the unique features practiced all along the mountain slopes is the use of split bamboos as water-carrying channels or pipes for irrigating the crops, suggesting co-evolution of this type of irrigation system along with adjacent Meghalaya and Assam. This is a cost-effective, indigenous practice developed by the farmers for irrigation of plantation crops such as coffee, tea, and cardamom. Agriculture has been flourishing in this area because of the development of such irrigation facilities. Split bamboos provide uninterrupted irrigation and control of the water channels.

Figure 2. Adoption and intensification of rubber plantation in Tripura.

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Further, to support sustainable agriculture, the farmers of the region have developed several improved indigenous farming systems (Sharma and Prasad, 1994). Some of the important ones are: *Zabo* farming system, which is practiced in the Phek district of Nagaland. This is a composite farming system with a combination of forestry, agriculture, livestock, and fisheries. *Zabo* means impounding of water. This farming system is followed in areas coming under the rain-shadow zone. Due to deforestation or less density of forests, the rainfall in these areas has been adversely affected. Therefore, tribal farmers of the area developed this system with their ingenuity, skill, and the experience gathered over a long time. Forestry is an important component of this system. It is common on the hill slopes, up to 100%. Under this system, the first component consists of the top of the hill and up to some area below, where forests are maintained. This works as the catchment area for rainwater harvesting. The second component consists of the area, a little down below, where the water is collected in ponds that are dug according to the size of the catchment and expected quantity of water. These ponds are used as de-siltation tanks and, after keeping the water for 2 to 3 days in these ponds, it is transferred to a larger main tank. The de-siltation ponds are de-silted

every year and the material, which contains a good amount of organic matter and nutrients, is put in the terraced rice fields to improve the fertility. The third component consists of livestock enclosures, where the tribal farmers keep their animals in bamboo enclosures a little below the main water storage tank. Generally, a few families keep their animals together in one enclosure. The fourth component is the rice fields, which, at the time of irrigation, get the water from the main tank. The water is passed through the livestock enclosures, to enable carrying the dung and urine of the animals to the fields along with the flow. Consequent to the availability of sufficient amount of nutrients, which are added to the water used for irrigation, the farmers get a yield of 3 to 4 tons of rice per ha without the additional application of fertilizers. Also, the fields get enriched with organically rich water. Under this system, the half-moon terracing of fields is useful in slope stabilization and also in allowing the percolation of rainfall into the ground (Fig. 3). This ingenious system helps in soil stabilization and enhances soil fertility and thus provides optimum crop yield.

Under the *zabo* system, keeping the major portion of the top of the hill slopes as forests also helps in perpetuation of grasses, which are used for feeding the cattle and other animals. Further, it helps in keeping the soil erosion to a minimum, thereby maintaining the ecological balance in the area and ensuring environmental benefits. The tribal farmers themselves take care of the forest land and other components of the system through tribal laws, which are very strict and followed by everyone dutifully. No one is allowed to cut trees or destroy vegetation, and proper care is taken collectively for the protection of the forest land.

Another system, called the alder system, is also followed in Nagaland. This involves planting of the alder trees to enhance the soil fertility with crops such as maize, Job's Tears, millet, potato, chili, pumpkin, barley, etc. (Fig. 4). The alder grows well on lands varying in altitude from 800 to 3,000 m. It is a non-leguminous tree that fixes atmospheric nitrogen through nodules on the roots. Besides fixing atmospheric nitrogen, the litter of the trees add to the soil phosphorus,

Figure 3. Half-moon terracing in the *zabo* farming system for greater soil stabilization and percolation of rainfall.

Figure 4. Stumps of alder (*Alnus nepalensis*) under the alder agroforestry farming system.

Terrace cultivation is widely practiced by the tribal communities. The major crops include rice, maize, millets, pea, oilseeds (rapeseed/mustard and niger), fibers, sugarcane, tobacco, potato, etc.

potassium, calcium, and other nutrients through the addition of biomass (Sharma and Singh, 1994). Alder is a multipurpose tree that, besides improving soil fertility, provides timber for furniture and fuelwood. The value of the alder tree was recognized by the tribal farmers a long time ago, as trees that are more than 200 years old can be seen in the area. Agricultural crops, together with the alder trees, help form a very remunerative agroforestry system, and the ability of the tree to develop and retain soil fertility has been fully utilized by the tribal farmers of the Angami, Chakhasang, Chang, Yimchaunger, and Konyak tribes (Gokhle *et al*., 1985). The Knononome village in the Kohima district of Nagaland is proud of its alder plantation and alder tree-based agriculture.

Recognizing the importance of the alder, its multiplication through the process of pollarding has been developed and practiced. The alder tree is ready for pollarding after 6 to 8 years, when the bark is rough and develops fissures. The alder is pollarded at a height of 2 to 2.5 m by the farmers, and the leaves and succulent twigs are incorporated in the field. The trunk then sprouts, giving new shoots called coppices. One alder tree sprouts approximately 100 to 200 coppices after pollarding. About 5 to 6 coppices are left on the main trunk for regeneration. It has been estimated that if a village of 100 families could set aside about 120 ha of land to grow alder trees, all families would get sufficient cereals, vegetables, firewood, etc. The pollarding is done from November to January, and the fresh cut is covered with stone to protect it from frost injury. Maintenance of alder trees is necessary for their long life. The trunk of the tree needs to be kept free of parasitic growth. In addition, there are practices such as swidden farming supported by women folk facilitating the conservation of crop diversity.

Further, to support sustainable agriculture, the farmers of the region have developed several improved indigenous farming systems.

Representative crop species in various crop groups

Cereals, pseudocereals, and millets. Barley (*Hordeum vulgare* L.), chenopodium (*Chenopodium album* L.), *Coix lacryma-jobi* var. *ma-yuen* (soft-shelled forms), finger millet (*Eleusine coracana*), foxtail millet [*Setaria italica* (L.) P. Beauv.], grain amaranth (*Amaranthus hypocondriacus* L., *A. paniculatus* L.), maize (*Zea mays* L.), rice (*Oryza sativa* L.), sorghum [*Sorghum bicolor* (L.) Moench], wheat (*Triticum aestivum* L.).

Legumes and oilseeds. Castor (*Ricinus communis*), cowpea (*Vigna unguiculata* (L.) Walp., mustard [*Brassica juncea* (L.) Czern.], niger (*Guizotia*

abyssinica Cass.), pigeonpea [*Cajanus cajan* (L.) Druce], rice bean [*Vigna umbellata* (Thunb.) Ohwi & H.Ohashi], winged bean [*Psophocarpus tetragonolobus* (L.) D.C.] and a few other Indian beans.

Fiber and forage. China grass [*Boehmeria nivea* (L.) Gaudich., *B. platyphylla* D.Don, *B. macrophylla* D.Don], jute (*Corchorus capsularis* L.), kuduzu vine [*Pueraria lobata* (Willd.) Ohwi (syn. *P. montana* (Lour.) Merr), *P. thunbergiana* Benth., *P. edulis* Pamp., *P. lobata* (Willd.) Ohwi *var. thomsonii*]: forage and medicinal, Nepal hemp (*Maoutia puya* Wedd.), sunnhemp (*Crotalaria meeboldii* Dunn).

Vegetables and tuber crops. Ash gourd [*Benincasa hispida* (Thunb.) Cogn.], bell pepper (*Capsicum annuum* var. *grossum* Sendt.), bitter gourd (*Momordica charantia* L.), brinjal (*Solanum melongena* L.) and other *Solanum* spp. used as vegetables and medicine (*S. xanthocarpum* Schard & Wendl; *S. indicum* L., *S. berbisetum* Nees), broccoli (*Brassica oleracea* L. var. *gemmifera*), cabbage [*Brassica oleracea* L. var. *capitata* (L.) Alef.], carrot (*Daucus carota* L.), cassava (*Manihot esculenta* L.), cauliflower (*Brassica oleracea* L. var. *botrytis* L.), chili (*Capsicum annuum* L. var. *avicular*), cho-cho [*Sechium edule* (Jacq.) Sw.], cucumber (*Cucumis sativus* L.), French bean (*Phaseolus vulgaris* L.), kankro (*Momordica dioica* Roxb. ex Willd.), knoll-khol (*Brassica olearacea* var. *gongylodes*), long pepper (*Capsicum annuum* var. *longum* Sendt.) and other introduced cultivated *Capsicum* species [*C. chinense* Jacq, *C. eximium* Hunziker, *C. frutescens* L., *C. minimum* Roxb. (syn. *C. fastigiatum* Bhumme), *C. pubescens* Ruiz. and Paron], *meetha karela* [*Cylanthera pedata* (L.) Schrader], *Moghania vestita* Benth ex Bak., okra [*Abelmoschus esculentus* (L.) Moench], pea (*Pisum sativum* L.), pointed gourd (*Trichosanthes dioica* Roxb.) in Tripura, pumpkin (*Cucurbita pepo* L.), *sem* (*Dolichos lablab* L.), snake gourd (*Trichosanthes anguina* L.), sponge gourd (*Luffa cylindrica* M.Roem.), sweet gourd [*Momordica cochinchinensis* (Lour.) Spreng.], sword bean [*Canavalia gladiata* (Jacq.) DC.], tomato (*Lycopersicon esculentum* Mill.); leafy vegetables – amaranth (*Amaranthus* L. spp.), *lai* [*Brassica juncea* (L.) Hook.f. & Thomson], *lafa* (*Malva verticillata* L.), spinach (*Spinacia oleracea* L.), *puroi sag* (*Basella rubra* and *B. alba*), sorrel (*Rumex rasicarius*); root and tuber vegetables – *arvi*/taro [*Colocasia esculenta* (L.) Schott], chives (*Allium tuberosum* Rottl. Ex Spreng.), East Indian arrowroot (*Curcuma angustifolia* Dalzell & A.Gibson), elephant-foot yam (*Amorphophallus bulbifer* Blume var. *bulbifer*, *A. bulbifer* Blume var. *atro-viridi*, *A. bulbifer* Blume var. *tuberculiger*), garlic (*Allium sativum* L.), giant taro [*Alocasia macrorrhiza* (L.) G.Don], greater yam (*Dioscorea alata* L.), lesser yam [*Dioscorea esculenta* (Lour.) Burkill], onion (*Allium cepa* L.), potato (*Solanum tuberosum* L.), potato yam/*ratalu* (*Dioscorea bulbifera* L.), radish (*Raphanus sativus* L.), sweet potato (*Ipomoea batatas*), taro (*Alocasia indica* Schott.; syn. *Arum indicum* Roxb. Sans), turnip (*Brassica rapa*

L. ssp. *rapa*), and yam bean (*Pachyrhizus erosus*): also a tuber crop (Edison *et al.*, 2005). In addition, edible bamboo shoot in Manipur only is consumed at approximately 60 kg/person/year. Cruciferous vegetables namely cauliflower, cabbage, knoll-khol, etc., were introduced during the days of the East India Company in the 14th to 15th century when European traders visited this region (Seshadri and Srivastava, 2002).

Spices. Bayleaf/*tejpat* (*Cinnamomum tamala* T.Nees & Eberm.), Bengal cardamom (*Amomum aromaticum* Roxb.), large cardamom (*Amomum subulatum* Roxb.), camphor tree [*Cinnamomum glanduliferum* (Wall.) Meisn., *C. pauciflorum* Nees], snap ginger [*Alpinia calcarata* (Roscoe) Merrill, *A. malaccensis* (Burm. f.) Roscoe], ginger (*Zingiber officinale* Roscoe), kaempferia (*Kaempferia galangal* L.), black pepper (*Piper nigrum* L.), long pepper (*Piper longum* L.), *P. peepuloides* Roxb., turmeric (*Curcuma longa* L.).

Fruits. Almond [*Prunus dulcis* (Mill.) DA Webb.; syn. *P. amygdalus* Batsch.], *aonla* (*Emblica officinalis* Gaertn), apple (*Malus sylvestris* L.), apricot (*Prunus armeniaca* L.), bael (*Aegle marmelos* Correa), banana (*Musa acuminata* Colla., *M. balbisiana* Colla., *M. flaviflora*), chestnut (*Castanopsis indica* Roxburgh ex Lindley), China-Brime [*Pyrus pyrifolia* Nakai; *P. serotina* Rehd.] is grown semi-commercially in Manipur and other places, grape (*Vitis vinifera* L.), guava (*Psidium guajava* L. Links), Himalayan bird cherry [*Prunus cornuta* (Wall. ex Royle) Steud.], *ichang papeda* (*Citrus ichagensis* Swingle), Indian crab apple (*Docynia indica* Decne., *D. hookeriana* Decne.), jackfruit (*Artocarpus heterophyllus* Lam.) grows abundantly in Tripura, Khasi *papeda* (*Citrus latipes* Hook.f. & Thomson ex Hook.f.), litchi [*Litchi chinensis* (Gaertn.) Sonne.], low chilling peaches [*Prunus persica* (L.) Batsch], mandarin (*Citrus reticulata* Blanco), mango (*Mangifera indica* L.), mangosteen (*Garcinia* L. spp.), melon (*Cucumis melo* L.), papaya (*Carica papaya* L.), passion fruit (*Passiflora edulis* Sims) (recent introduction), peach (*Prunus persica* Benth & Hook.f.), pear (*Pyrus communis* L.), pineapple [*Ananas comosus* (L.) Merr.], plum (*Prunus domestica* L.), sour cherry (*Prunus cerasoides* D.Don) in Manipur, sour orange (*Citrus aurantium* L.), starfruit (*Averrhoa carambola* L.), strawberry (*Fragaria vesca* L.).

Beverage, plantation, and other crops. Arecanut (*Areca catechu* L., *A. nagensis* Griff., a rare substitute), black cardamom (*Amomum subulatum* Roxb.), coconut (*Cocus nucifera* L.) in Tripura, coffee (*Coffea arabica* L.), dye – *Rumex nepalensis* Spreng. (roots), *Mahonia nepalensis* DC. ex Dippel (bark), *Dichroa febrifuga* Lour. (fruits), *Symplocos glomerata* King ex Gamble (leaves), indigo leaves (*Indigofera tinctoria* L., *I. dosua* Wall., *I. heterantha* Wall.), *Bixa orellana* L. (fruits); rubber [*Hevea brasiliensis* (Willd ex A. Juss.) Mull.Arg.]; sugarcane (*Saccharum officinarum* L.), tea (*Camellia sinensis* L.), tobacco (*Nicotiana tabacum* L., *N. rustica* L.).

Timber. Agar (*Aquilaria agallocha* Roxb.), alder/*utis* (*Alnus nepalensis*

D.Don); arjun (*Terminalia arjuna*), *Artocarpus chama*, *bahera* (*Terminalia bellirica* Roxb.), chir pine (*Pinus roxburghii* Sarg., *P. wallichiana* A.B.Jacks.), *gamar* (*Gmelina arborea* Roxb. ex Sm.), *garjan* (*Dipterocarpus turbinatus*) in Tripura, Himalayan cypress (*Cupressus torulosa* D.Don), Himalayan hemlock (*Tsuga dumosa* Eichl.), hollock (*Terminalia myriocarpa* van Heurck & Muell.-Arg.), hollong (*Dipterocarpus retusus* Blume), Japanese cedar (*Cryptomeria japonica* D.Don), *koroi*/siris (*Acacia lebbeck* Willd.), red cedar (*Toona ciliata* M.Roem.), sal (*Shorea robusta*, *S. assamica* Dyer), teak (*Tectona grandis*) – Tripura, walnut (*Juglans regia* L.).

Bamboos and canes. A number of species of bamboo occur and are cultivated in the region; the dominant ones are *anthi bans* (*Dendrocalamus strictus* Nees), *Arundinaria callosa* Munro, *A. hookeri* Munro ex Keng, *Bambusa kingiana* Gamble, *B. nana* Roxb., *B. nutans* Wall. ex Munro, *B. oliveriana* Gamble, *barak* (*Bambusa balcooa* Roxb.), *bari* (*Bambusa polymorpha* Munro), *Dendrocalamus calostachys* Kurz., *D. giganteus* Munro, *D. hookeri* Munro, *D. longifimbriatus* Gamble, *D. sericeus* Munro, *dolu* [*Schizostachyum dullooa* (Gamble) R.B.Majumdar], *kailyai* (*Gigantochloa rostrata* K.M.Wong), *kanak kaich* (*Bambusa affinis* Munro), *lik* [*Sinarundinaria intermedia* (Munro) C.S.Chao & Renvoize], *makal* (*Bambusa pallida*), *mautak* (*Melocanna baccifera*; syn. *M. bambusoides*), *Neomicrocalamus prainii* (Gamble) Keng f., *paora* (*Bambusa teres* Buch.-Ham.), *phar* (*Chimonobambusa callosa* Nakai), *phulrua/pecha* (*Dendrocalamus hamiltonii*), *rawmi* (*Dendrocalamus sikkimensis* Gamble ex Oliv.), *rawnal rupai* (*Dendrocalamus longispathus* Kurz), *rawngal* [*Schizostachyum capitatum* (Munro) R.B.Majumdar], *rawte* (*Bambusa khasiana* Munro), *rawthing tial* [*Gigantochloa albociliata* (Munro) Kurz], *rawthing/mritinga* (*Bambusa tulda* Roxb.), *sairil* [*Dinochloa compactiflora* (Kurz) McClure], *sairil/wadu* bamboo (*Melocalamus compactiflorus* Benth.), *Schizostachyum fuchsianum* (Gamble) R.B.Majumdar, *S. polymorphum* (Munro) R.B.Majumdar, *Sinarundinaria elegans* (Kurz) C.S.Chao & Renvoize, *S. griffithiana* (Munro) C.S.Chao & Renvoize, *S. nagalandiana* Naithani, and *S. rolloana* (Gamble) C.S.Chao & Renvoize. Almost all the species of bamboos of northeastern India are available in Manipur. Manipur has bamboo forests of 11,700 km^2, which is 5.7% of the total area of the country. In canes, this region has the highest diversity with species of *Calamus*, *Daemonorops*, and *Plectocomia* (Thomas, 2002).

Other economic plants

Minor vegetables. Amaranth (*Amaranthus caudatus* L., *A. viridis* L., *A. lividus* Hort. Petrop. ex Hook.f., *A. retroflexus* L., and *A. spinosus* L.), bamboo shoots (*Bambusa tulda*), *Canavalia ensiformis* (L.) DC., *Clinogyne dichotma* Salisb. (edible tubers), fern [*Diplazium esculentum* (Retz.) Sw.], *jilmilsag* (*Chenopodium album* L.), *kalmou sag* (*Ipomoea reptans* Poir.), *Polygonum*

alatum Hamilton ex D.Don, *P. hydropiper* L., sessile joyweed [*Alternanthera sessilis* (L.) R.Br. ex DC.], *Solanum torvum* Swartz. (W), *Vigna vexillata* (L.) A. Rich., legume-cum-tuber crop in Tripura.

Minor fruits. Burmese grape (*Baccaurea ramiflora* Lour.), *chaplaish* (*Artocarpus chaplasha*), chocolate fruit (*Diospyros lanceafolia* Roxb.), *Clausena dentata* (Willd.) M. Roemer, *C. excavata* Burm. f. (fruits edible), elephant apple (*Dillenia indica*, Linn), elephant ear fig tree (*Ficus auriculata* Lour.), fig (*Ficus carica* L., *F. pomifera* Wall. ex King), hazelnut (*Corylus ferox* Wallich), *kayaphal* (*Myrica esculenta* Buch.-Ham. ex D.Don), *khachur* (*Cornus macrophylla*), *lacpche kawala* (*Machilus edulis* King ex Hook.f.), mangosteen [*Garcinia atroviridis* Griff. ex T.Anderson, *G. pedunculata* Roxb. (large edible fruits used in curries), *G. sopsopia* (Buch.-Ham.) Mabb. (fruits edible and stem used as a rootstock for mangosteen), *G. stipulata* T.Anderson, *G. xanthochymus* Hook.f.], monkey jack (*Artocarpus lakoocha* Roxb.), mullberry (*Morus alba* L.), *Pegia nitida* Colebr., persimmon (*Diospyros nigrescens*), *phalsa* (*Grewia oppositifolia* Roxb.), *Prunus napaulensis* (Ser.) K.Koch, *P. rufa* Steud., *Pyrularia edulis* A.DC., *Pyrus wattii* (Koehne) Bennet, *Rubus ellipticus* Sm., *saklang* (*Elaeocarpus lanceafolius* Roxb.), *Salacia roxburghii* Wall. (fruit edible), *Saurauia cerea* Griff. ex Dyer, *S. punduana* Wall., *S. roxburghii* Wall. (fruit edible), silverberry (*Elaeagnus latifolia* L. and *E. pyriformis* Hook.f.).

Medicinal plants. Agarwood/*agor* (*Aquilaria agallocha*), bayleaf/*tejpat* (*Cinnamomum tamala*), Bengal cardamom/ *van elaichi* (*Amomum aromaticum*), *bhandhanya* (*Eryngium foetidum* L.), black myrobalan/*harar* (*Terminalia chebula* Retz.), black turmeric/black zeodory/*yaimu* (*Curcuma caesia* Roxb.), *chab* (*Piper brachystachyum* Wall.), *chireta* (*Swertia paniculata* Wall., *S. macrosperma* C.B.Clarke), common yew/ *thuno* (*Taxus baccata* L. var. *wallichiana*), curculigo (*Curculigo orchioides* Gaertn.), East Indian arrowroot/*yaipal* (*Cucurma angustfolia*), Flame of the Forest (*Butea monosperma* Kuntze), *galanga* (*Alpinia galanga* Willd.), *giloe* [*Tinospora cordifolia* (Willd.) Hook.f. & Thomson], ginger lily (*Hedychium coronarium* J.Koenig), ginseng (*Panax schinseng*), *hadjod* [*Cissus quadrangula* L.; syn. *Vitis quadrangula* (L.) Wallich ex Wight & Arn.], *heimang* (*Rhus semialata* Murr.), *Hodgsonia macrocarpa* Cogn. (syn. *Trichosanthes macrocarpa*), Indian berberry (*Berberis lyceum* Royle, *B. feddii* Ahrendt., *B. micropetala* Schneider, *B. wardii* Schneider), costus (*Costus speciosus* Sm.), Indian sichuan pepper (*Zanthoxylum rhetsa* D.C.), *kuthap* (*Clerodendrum colebrookianum* Walp.), mango ginger (*Curcuma amada* Roxb.), *moirang khanambi* (*Clerodendrum serratum* Spreng), narrow-leaved Indian mulberry (*Morinda angustifolia* Roxb.), notoginseng [*Panax pseudoginseng* (Burkill.) Hoo. & Tseng.]; nux-vomica (*Strychnos nux-vomica* L.), *Rhus javanica* L., *sarpagandha* (*Rauvolfia serpentina* L.), *Smilax lanceaefolia* Roxb., spiked ginger lily (*Hedychium spicatum* Sm.), sweet flag (*Acorus calamus* L.), wild

turmeric (*Curcuma aromatic* Salisb.), winged treebean [*Vitis quadrangularis* (L.) Wall. ex Wight & Arn.], zedoary/*kachoora* (*Curcuma zedoaria* Rosc.).

Ornamentals. The native species of orchids usually belong to genera, such as *Aerides* Lour., *Arundina* Blume, *Cymbidium* Sw., *Dendrobium* Sw., *Paphiopedillium* Piftzer, *Phaius* Lour., *Renanthera* Lour., and *Vanda* Jones ex R.Br. etc., having ornamental value and market potential (Borthakur, 1992). Other common ornamental species are: Himalayan flowering dogwood [*Benthamidia capitata* (Wall.) H. Hara.], ginger lily (*Hedychium coronarium* J.Koenig, *H. greenii* W.W.Sm. var. *urophyllum, H. speciosum* Wall.), ixora (*Ixora acuminate* Roxb., *I. undulata* Roxb.), jasmine (*Jasminum attenuatum* Roxb., *J. azoricum* Hook. & Arn., *J. flexile* Desf. ex DC., *J. lanceolarium* Roxb.), palm (*Livistona jenkinsiana* Griff.), Manipur lily (*Lilium mackliniae* Sealy), dancing girl (*Mantisia saltatoria* Sims), *Michelia champaca* L., pinga palm (*Pinanga gracilis* Blume, *P. griffithii* Becc.), rose [*Rosa odorata* Sweet (syn. *R. gigantea* Collett ex Crép.), *R. longicuspis* Bertol., *R. macrophylla* Lindl., *R. sericea* Lindl.], and orchids – *Arachnis labrosa* Rchb.f. *Bulbophyllum guttulatum* (Hook.f.) Balakr., *Clesostoma racemiferum*, *Cymbidium elegans* Lindl., *Coelogyne corymbosa* Lindl., *Dendrobium chrysanthum* Wall., *D. heterocarpum* Wall. ex Lindl., *D. longicornu* Lindl., *D. nobile* Lindl., *D. ochreatum* Lindl., *D. wardianum* Warner, *Paphiopedilum hirsutissimum* Pfitzer, *Pleione maculata* Lindl. & Paxton, *P. praecox* D.Don, Red Vanda (*Renanthera imschootiana* Rolfe, *Rhynchostylis retusa* Blume.), Blue Vanda (*Vanda coerulea* Griff. ex Lindl.) and rhododendron – *Rhododendron triflorum* Hook.f. var. *bauhiniflorum* (Watt ex Hutch.) Cullen, *R. wattii* Cowan, *R. formosum* Wall., *R. johnstoneanum* Watt ex Hutch., *R. macabeanum* Watt ex Balf.f., and *R. elliottii* Watt. In addition, species belonging to *Mannolia*, *Cassia*, *Erythrina*, *Calustemom*, *Dacasenda*, *Myrica*, *Bauhinia*, etc. have necessary potential.

Multipurpose species. The common multipurpose species are alder (*Alnus nepalensis*), *rudraksh* (*Elaeocarpus floribundus*), *Ficus cunia*, *phalsa* (*Grewia oppositifolia*) – fruit, medicinal, castor (*Ricinus communis*), mulberry (*Morus alba* L.) – rearing silkworm, and seed/fruit, *Zanthoxylum rhetsa* (Roxb.) DC. – essential oil and spice. In parts of Manipur and Mizoram, the tree bean (*Parkia roxburghii* G. Don.; syn. *P. timoriana*) is one of the most common multipurpose tree species yielding good timber, and also provides edible flowers and pods that are highly prized (Kumar *et al*., 2002). In the hilly areas, tree tomato (*Cyphomandra betacca*), a perennial shrub producing red tomato-like vegetables, is also grown and used as such. Another tree growing in the lower altitudes is the drumstick or horse-radish, locally called *sajina* (*Moringa oleifera* Lam.). Many orchids have been used as medicinal agents by the tribals of Nagaland, Meghalaya, and Mizoram. For example, the juice of the *Vanda* flower is used as eye drop to cure glaucoma.

Wild relatives of crop species. *Alocasia cucullata* (Lour.) G. Don, *A. macrorhiza* Schott., *Camellia caudata*, *Canavalia gladiata* (Jacq.) DC., *C. virosa* (Roxb.) Wight & Arn. (Manipur, Mizoram), *Citrus jambhiri* Lush., *C. indica* Tanaka, *C. macroptera* Montrouz., *Coffea bengalensis* Roxb., *Corchorus pseudo-olitorius* Islam & Zaid, *Cucumis hardwickii* Royle, *C. hystrix* Chakrav., *Curcuma aeruginosa* Roxb., *C. brog* Valeton, *C. comosa* Roxb., *C. latifolia* Rosc., *C. sylvatica* Valeton, *C. soloensis* Valeton (Ravindran *et al.*, 2005), *Diospyros lotus* Linn., *Dioscorea alata* L., *D. brevipetiolata* Prain & Burkill, *D. lepcharum* Prain & Burkill, *D. pentaphylla* Wall., *D. decipiens* Hook.f., *D. hamiltonii* Hook.f., *D. hispida* Dennst., *D. lepcharum* Prain & Burkill, *D. nummularia* Lam., *D. prazeri* Prain & Burkill, *D. pubera* Blume, *D. trinervia* Roxb. ex Wall., *D. wattii* Prain & Burkill), *Dolichos falcatus* Klein ex Willd., *Garcinia cowa* Roxb., *G. lanceaefolia* Roxb., *G. spicata* Kurz ex Talbot, *Gossypium arboreum* L., *Hibiscus furcatus* Roxb., *Erianthus ravennae* P.Beauv. (syn. *Saccharum ravennae* L.), *Indigofera dosua* Buch.-Ham. ex D.Don., Himalayan indigo (*Indigofera heterantha* Brandis), *Leersia hexendra* Swartz. (Manipur), *Luffa aegyptiaca* Mill., *L. graveolens* Roxb., *Malus baccata* (L.) Borkh., *Mangifera sylvatica* Roxb., *Miscanthus nepalensis* Hack., *M. nudipes* (Griseb.) Hack., *M. taylorii* Bor, *M. wardii* Bor (hybridized with *Saccharum*), *Momordica macrophylla* Gage, *M. subangulata* Blume, *Mucuna bracteata*, *Musa acuminata* L., *M. balbisiana* Coll, *M. itinerans* Cheesman, *M. superba* Roxb. (Manipur), *M. flaviflora*, *M. nagensium* (Nagaland), *Myrica esculenta* Buch.-Ham. ex D.Don, *Narenga fallax* (Balansa) Bor (hybridized with *Saccharum*), *Nicotiana excelsior* (J.M. Black), *Olea dentata* Wall. ex DC., *Oryza granulata* Nees et Arn. ex Steud. (foothills), *Phoenix acaulis* Buch-Hum., *P. robusta* Hook.f., *P. rupicola* T.Anderson, *Piper attenuatum* Buch.-Ham. ex Wall., *P. aurorubrum* C.DC., *P. falconeri* C.DC., *P. hamiltonii* C.DC., *P. makruense* C.DC., *P. meeboldii* C.DC., *P. sylvaticum* Roxb., *P. wallichii* Hand.-Mazz., *Prunus acuminata* Hook.f., *P. arborea* (Blume) Kalkman, *P. jenkinsii* Hook.f., *P. undulata* Buch.-Ham., *Pyrus pashia* Buch.-Ham. ex D.Don, *Rumex dentatus* Wall., *Saccharum longisetosuma* (Anderson) V.Naray ex Bor, *S. procerum* Roxb., *S. rufipilum* Steud., *Sclerostachya fusca* A.Camus (hybridized with *Saccharum*), *Solanum khasianum* C.B.Clarke, *S. bracteatum* Thunb., *S. kurzii* Brace ex Prain, *S. spirale* Roxb., *S. torvum*, *Sorbus aucuparia* L., *S. vistita*, *Trichosanthes cucumerina* L., *T. wallichiana* Wight, *T. bracteata* Voigt, *T. cordata* Roxb., *T. himalensis* C.B.Clarke, *T. tomentosa* Chakrav., *Vigna capensis* (L.) Walp., *V. clarkei* Prain, *Vigna radiata* (L.) Wilczek var. *sublobata* (Roxb.) Verdc, *Ziziphus funiculosa* Buch.-Ham. ex M.A. Lawson, Bengal ginger (*Zingiber rubens* Roxb., *Z. casumnar* Roxb.) (Arora and Nayar, 1984, and others).

Endemic species. The following economically important species have been reported endemic from the region: *Agrostis wardii* Bor., *Albizia kalkora* (Roxb.),

Areca nagenis Griff., *Berberis borealis* Takeda var. *parryii* Ahrendt, *B. feddii* Ahrendt, *B. micropetala*, *B. sublevis* var. *sublevis*, *B. wardii*, *Capparis cinerea* Jacobs, *Carex asraoi* D.M.Verma, *Cotoneaster nagensis* Klotz, *Crotalaria meeboldii* Dunn, *Dalbergia wattii* C.B.Clarke, *Derris lushaiensis* Thoth, *Eulalia manipurensis* Bor, *Hedychium gratum*, *H. venustum*, *Impatiens cuspidifera* Hook.f., *Lilium imacklineae* Sealy, *Maesa macrophylla* Wall. var. *magnidentata* Nayar, *Mahonia magnifica* Ahrenett, *M. roxburghii* (DC.) Takeda, *Pimpinella evoluta* (Clarke) P.K. Mukh., *P. flaccid* Clarke, *P. nervosa* C.B.Clarke, *Piper aurorubrum* C.DC. (S&M), *P. falconeri* C.DC., *P. liantakanum* C.DC., *P. makruense* C.DC., *P. meeboldii* C.DC., *P. muneyporensis* C.DC., *P. phalagense* C.DC., *Rhododendron elliottii* Watt ex Brandis, *R. johnstoneanum* Watt ex Hutchinson, *R. macabeanum* Watt ex Balf.f., *R. trifolium* Hook.f. var. *bauhiniflorum* (Watt ex Hutch.) Cullen, *R. wattii* Cowan, *Rhynchosia meeboldii* Satyan. & Thoth., *Saussurea nagensis* C.E.C. Fischer, *Trichosanthes tomentosa* Chakravarty (Nayar, 1996). Table 1 lists some representative economic plant species endemic to the region.

Threatened economic species. Some representative economic species reported under threat are: *Anoectochilus tetrapterus* Hook.f., *Bulbophyllum rothschildianum* (O'Brien) J.J. Smith, *Calanthe anthropophora* Ridley, *Capparis cinerea* Jacobs, *Ceropegia angustifolia* Wight, *Ceropegia arnottiana* Wight, *Ceropegia lucida* Wall., *Dendrobium auranticum* Rchb.f., *Dioscorea deltoidea* Wall. ex Griseb., *Diplomeris hirsuta* (Lindl.) Lindl., *D. pulchella* D. Don, *Elaeocarpus prunifolius* (C. Muell.) Mast., *Ixonanthus khasiana* Hook.f., *Lagerstroemia minuticarpa* Debberm. ex P.C. Kanjilal, *Lilium macklineae* Sealy, *Magnolia griffithii* Hook.f. & Thoms., *M. gustavi* King, *Mangifera khasiana* Pierre, *Pachylarnax pleiocarpa* Dandy, *Paphiopedilum spicerianum* (Rchb.f. ex Masters & T.Moore) Pfitz., *P. venustum* (Wall.) Pfitz. ex Stein, *P. villosum* (Lindl.) Stein, *P. wardii* Summerh., *Papilionanthe vandarum* (Rchb. f.) Garay (= *Aerides vandarum* Rchb. f.), *Phoenix rupicola*, *Picea brachytyla* (Franch.) Pritzel var. *complanata* (Masters) Cheng ex Rehder, *Renanthera imschootiana* Rolfe, *Rhododendron elliottii*, *R. formosum* Wall., *R. johnstoneanum*, *R. wattii*, and *Vanda coerulea* (Nayar, 1996). *Citrus indica* and *C. macroptera* are the wild endangered species of *Citrus* occurring in northeastern India, including Mizoram (Malik *et al.*, 2006). Recently, Singh and Singh (2009) reported that 14 plant species of medicinal value, sweet flag (*Acorus calamus* L.), agarwood/*agor* (*Aquilaria agollocha*), Flame of the Forest (*Butea monosperma*), bayleaf/*tejpat* (*Cinnamomum tamala*), *kuthap* (*Clerodendrum colebrookianum*), *moirang khanambi/bharangi* (*Clerodendrum serratum* Spreng.), East Indian arrowroot/*yaipal* (*Curcuma angustifolia*), black zeodoary/*yaimu* (*Curcuma caesia*), ginger lily (*Hedychium coronarium*), spiked ginger lily (*Hedychium spicatum* Sm.), ginseng (*Panax schinseng*),

Table 1. Representative agriculturally important species endemic to the Northeastern Hills: Nagaland, Manipur, Mizoram and Tripura.

Species	Family	Habit	Distribution	Use
Albizia kalkora	Mimosaceae	Tree	Nagaland and Jaintia hills	Wild genetic resource
Areca nagensis	Arecaceae	Tree	Nagaland	Masticatory, solitary plant at the Indian Botanical Garden
Berberis feddii	Berberidaceae	Shrub	Manipur hills; 2500 m	Medicinal, golden yellow flower
Berberis micropetala	Berberidaceae	Shrub	Naga hills	Medicinal, white flower
Berberis sublevis var. *sublevis*	Berberidaceae	Shrub	Manipur hills; 1,500–2,500 m	Medicinal
Carex asraoi	Cyperaceae	Herb	Nagaland	Forage
Cotoneaster nagensis	Rosaceae	Shrub	Naga hills	Cane, used for making baskets
Dalbergia watii	Fabaceae	Tree	Manipur	Wood, used for fuel
Impatiens cuspidifera	Balsaminaceae	Herb	Nagaland	Ornamental
Derris lushaiensis				Fish poison
Lilium mackinliae	Liliaceae	Bulbous herb	Narrow endemic, found in the eastern border area of Manipur	Pinkish white flowers, "Shirhoy Lily"; leaves used to treat skin disease
Maesa macrophylla var. *magnidentata*	Myrsinaceae	Large shrub	Nagaland	Source of light wood
Mahonia magnifica	Berberidaceae	Small tree	Manipur hills	Medicinal, with yellow flowers
Mahonia roxburghii	Berberidaceae	Shrub	Manipur hills	Medicinal
Piper aurorubrum	Piperaceae	Climbing shrub	Manipur	Spice and medicine, as uterine stimulant
Rhododendron elliottii	Ericaceae	Small tree	Naga and Manipur hills	Multipurpose
Rhododendron johnstoneanum	Ericaceae	Shrub	Manipur and Lushai hills	Multipurpose
Rhododendron macabeanum	Ericaceae	Tree	Manipur and Naga hills	Multipurpose
Rhododendron triflorum var. *bauhiniflorum*	Ericaceae	Shrub	Manipur; 2,450–2,750 m	Multipurpose
Rhododendron wattii	Ericaceae	Shrub or small tree	Manipur; 2,700–3,000 m	Multipurpose
Saussurea nagensis	Asteraceae	Herb	Naga hills, Nagaland	Medicinal
Trichosanthes tomentosa	Cucurbitaceae	Scandent herb	Naga hills, Nagaland	Wild genetic resource

sarpagandha (*Rauvolfia serpentina*), *heimang* (*Rhus semialata* Murr.), common yew (*Taxus baccata* L. var. *wallichiana*; *thuno*), available in Manipur, have been listed by the International Union for the Conservation of Nature and Natural Resources (IUCN) as endangered species. Table 2 lists some economic plant species reported to be under threat.

Associated culture

Northeastern India in general, and the Northeastern Hills in particular, are a bouquet full of unique treasures of Mother Nature, least explored and the most pristine. Besides, being the most enriched region of flora and fauna, and distinct culture, it is home to various indigenous tribal communities belonging to the Austro-Asiatic linguistic family. It is predominantly inhabited by Mongoloid, Indo-Mongoloid and Austric races, with the influence of Aryan culture and both Hindu and Christian religions. For example, Nagaland only has over 20 tribes, the largest being the Konyaks, then the Aos, Tangkhuls, Semas, Angamis, etc. Over time, these tribes remained relatively isolated from each other, and even today do not view themselves as one unified people. Despite this, they do share common cultural characteristics that help to create the loose, generic culture, which may be referred as "Nagaland culture". The tribes associated with agriculture are Airnol, Anal, Angami, Mao, Any Mizo, and Gongte in Manipur; Kuki, Nagas, Angami, and Kachan in Nagaland; Bhil, Bhim, Chakma, Kuki, and Khasia in Tripura; and Lushais in Mizoram. The major tribal communities of the region are:

Angami tribal community: Angami is one of the major tribal communities of Nagaland. Angamis are also found in Manipur. They have a huge population of 12 million. Their main occupation is agriculture. Every year they produce near about 20 varieties of paddy. Another major occupation of the Angamis is wood carving. Angami men are excellent craftsmen and masons, whereas women are expert weavers. Most of the Angami people follow Christianity.

Rengma tribal community: Rengma is another Naga tribal community. This community is found in both Nagaland and Assam. The Rengma community has a total population of nearly 51,000 in entire Nagaland. Rengmas are divided into the subcategories of Eastern Rengmas and Western Rengmas. They are expert terrace cultivators.

Lushais tribal community: Lushais are the aboriginal tribal community of Mizoram. Lushais are one of the major subgroups of the Mizos. They mostly inhabit the north Lushai hills and some parts of Assam and Manipur. These people are engaged in the collection of forest products and basket preparation. They follow Christianity.

Riang tribal community: Riang is a tribal community of Tripura. The Riangs mainly reside in the North and South Tripura districts and are engaged in *jhum* cultivation. They have a distinct culture and tradition and pay homage to 14 gods and goddess of the Tripura state.

Tribals have maintained and conserved the genetic diversity of wild and less-known

Table 2. Representative agriculturally important species under threat in the Northeastern Hills: Nagaland, Manipur, Mizoram, and Tripura.

Species[1]	Family	Habit	Threat level[2]	Use
Anacolosa densiflora	Oleaceae	Tree	R	Wood for toys and posts
*Capparis cinerea**	Capparidaceae	Shrub	I	Fruit, genetic resource
*Ceropegia lucida**	Asclepiadaceae	Twiner	EN/EX	Ornamental
Citrus indica	Rutaceae	Tree or shrub	EN	Fruit, genetic resource
C. macroptera	Rutaceae	Tree or shrub	EN	Fruit, genetic resource
*Dendrobium auranticum**	Orchidaceae	Herb	VU	Epiphyte, ornamental
*Dioscorea deltoidea**	Dioscoreaceae	Herbaceous climber	EN	Medicinal, tubers rich in saponin, used for washing
*Elaeocarpus prunifolius**	Elaeocarpaceae	Tree	VU	Edible fruit
*Ixonanthus khasiana**	Ixonanthaceae	Tree	VU	Wood for cabinet making
*Lilium mackinliae**	Liliaceae	Herb	EN	Ornamental
Magnolia gustavii	Magnoliaceae	Tree	VU	Ornamental
Mangifera khasiana	Anacardiaceae	Tree	I	Wild, genetic resource
*Paphiopedilum spicerianum**	Orchidaceae	Herb	CR	Ornamental
Papilionanthe vandarum	Orchidaceae	Epiphytic herb	I	Ornamental
*Phoenix rupicola**	Arecaceae	Tree	CR	Wild, farinaceous pith edible
*Renanthera imschootiana**	Orchidaceae	Epiphyte	VU in Mizoram and Nagaland	Ornamental
Rhododendron elliottii	Ericaceae	Tree or shrub	VU	Multipurpose
Rhododendron formosum	Ericaceae	Shrub	VU	Multipurpose
Rhododendron johnstoneanum	Ericaceae	Shrub	R	Multipurpose
Rhododendron triflorum var. *bauhiniflorum*	Ericaceae	Shrub or tree	EN	Multipurpose
Rhododendron wattii	Ericaceae	Shrub or tree	EN	Multipurpose
*Vanda coerulea**	Orchidaceae	Epiphytic herb	CR	Ornamental

1. * = Also listed by the Ministry of Environment and Forests, Governtment of India.
2. CR = Critically endangered; EN = Endangered; EX = Possibly extinct from wild; I = Indeterminate; R = Rare; VU = Vulnerable.

crop species in their *baris* (lands attached to their houses and huts), kitchen gardens and in their backyard fields. Some examples of such cultivated crops are *Piper peepuloides*, *Parkia roxburghii*, *Vigna umbellata*, *Inula racemosa* Hook. f., *Coix lacryma-jobi*, and *Digitaria cruciata* var. *esculanta* Bor. Tribal communities cultivate several species of *Alocasia*, *Amorphophallus*, *Colocasia*, and *Dioscorea* in their backyard home gardens. Another dimension for assuring the security of agrobiodiversity is the swidden farming adopted by the Angami tribal community of Nagaland. This involves the cultivation of 15 to 30 crop species in the same plot of land after *jhum* forest clearing. This is also called the "*female farming system*" as the women folk of the village are involved in sowing, manuring, weeding, seed selection, harvesting, and storage (Raju and Sarin, 2001).

Technology and products

The farmers of the region have developed several technologies and practices in interaction with the landscape to facilitate conservation and effective use of natural resources, and cultivation of economic plant species to meet their diverse demands of food and nutrition. The *zabo* farming system of Nagaland combines water conservation with forestry, animal care, and agriculture. Under this system, as the water runs along the slope, it passes through various terraces and gets collected in pond-like structures in the middle terraces; below are the cattle yards, and towards the foothills are paddy fields, where the runoff water ultimately meanders into. *Cheo-ozihi* is another irrigation system practiced in Kwigwma village, bringing river water through long channels. From these channels, many branch channels take the water to terraces through bamboo pipes. *Cheo* is the person responsible for laying the channels. The village water budget is shared among villagers. In addition, the farmer's practice of irrigation using water channels controlled by bamboo sticks, for plantation crops such as coffee, tea, and cardamom, facilitating the efficient use of water and ensuring uninterrupted water supply. The alder system is another good example, where a multipurpose tree has been exploited in agroforestry for sustaining the soil fertility in addition to other economic potential. *Alnus nepalensis* is also planted along margins of farms for increasing the soil fertility in lands that are under shifting cultivation.

The tribes associated with agriculture are Airnol, Anal, Angami, Mao, Any Mizo, and Gongte in Manipur; Kuki, Nagas, Angami, and Kachan in Nagaland; Bhil, Bhim, Chakma, Kuki, and Khasia in Tripura; and Lushais in Mizoram.

The diverse altitude and climatic conditions and topography of the region have been able to support cultivation of a large number of domesticated plant species, generating a spectrum of genetic variability under natural or farmer's selection pressures. The landraces of rice from the region have shown variability for short stature, gall midge resistance, waxy endosperm, etc. *Latisail*,

a landrace collected from Tripura, has been used along with the landraces from Indonesia, namely Intan, Mas, and Peta, and the Chinese variety 'Cina' Peta, as one of the parents in the development of IR 8, one of the outstanding varieties released from IRRI (International Rice Research Institute). As per one estimate, more than 80% of the semi-dwarf varieties grown in tropical Asia have *Latisail* germplasm, reflecting the outstanding contribution of the region to world agriculture.

In grain legumes, the region is known for several wild forms and high variability in rice bean (*Vigna umbellata*), with profuse branching types reported from Mizoram and Manipur; higher seeds per pod from Mizoram; higher number of pods per peduncle, bold seeds and high grain yield from Manipur; higher polymorphism has also been recorded in local landraces for seed color. Landraces with a rare uniform light green color occur in the Mao hills. Additionally, *Vigna radiata* var. *sublobata* is known for yellow mosaic virus resistance, whereas *V. umbellata* var. *radiata* is known for resistance to diseases and insect pests. Another interesting species, *V. vexillata* is grown by the tribals of Tripura. It is a legume-cum-tuber crop with much variation in edible tubers (Arora and Pandey, 1996). In French bean, climbing or pole type is popular among the tribals, since it is used for mixed cropping with maize, which acts as the support. Jack bean [*Canavalia ensiformis* (L.) DC.] is also cultivated on a limited scale (CSIR, 1950) whereas, winged bean (*Psophocarpus tetragonolobus*) is confined to the humid subtropical parts of the region (Sarma, 2001). The region is also known for genetic diversity in the case of oilseed crops, where significant variability has been recorded in Indian mustard, maximum variability in sesame, and cold tolerance types in case of niger.

The region, because of its diverse landscape, has its own unique combination of living species, habitats, and ecosystems, which together make up its rich resource diversity, especially in horticultural crops, which are mainly managed by local farmers, often women. Considerable diversity exists among the regional horticultural species, particularly for plant type, morphological and physiological characteristics, reactions to diseases and pests, adaptability and distribution. Apart from the nutritional value, many regional horticultural crops are used for medicinal purposes, generating income and helping in the poverty alleviation programs in the rural areas.

In vegetables, the region is part of the primary center of diversity for cucumber (*Cucumis sativus*). In addition, wild relatives of several cucurbits have also been reported from the region with significant genetic variability, such as *Cucumis hardwickii, C. hystrix, Luffa graveolens, Momordica cochinchinensis, Trichosanthes ovata, T. khasiana*, etc. (Sirohi *et al.*, 2005) providing a reservoir of useful genes. In solanaceous vegetables, the region is very rich in diversity for *Solanum melongena,* with several varieties having excellent quality of soft flesh, less seeds and large fruit size. Additionally, wild species, such as *S. torvum, S. indicum, S. khasianum*, etc., occur in the region. *Solanum khasianum* is an important

species of medicinal value (solasodine content) and so is *S. torvum,* extensively used in the Ayurvedic medicine system. These species have also been found to possess resistance to shoot and fruit borer, and root diseases respectively (Kalloo *et al.*, 2005). Three tomato varieties namely Manileima, Manikhamnu and Manithoibi, developed using local landraces, were released by the State Variety Release Committee, Manipur, and found suitable for rice-based cropping systems. *Lycopersicon pimpinellifolium,* naturalized to this region, has also expressed resistance to late blight and tomato leaf curl virus (Seshadri and Srivastava, 2002). The local tribals grow a vegetable having red tomato-like fruits slightly bitter in taste, but related to the brinjal and belonging to the genus *Solanum*. In Manipur, another kind of brinjal, having roundish fruit and intermediate in appearance between tomato and brinjal, is grown. Chilis are known to grow well in the warm to hot and humid climate of Manipur, Mizoram, Nagaland, and Tripura. Due to the long history of cultivation, outcrossing, and popularity of the crop, large genetic diversity has evolved in the form of a number of local landraces, with great variability for fruit shape, size, color, and bearing; semi-perennial and perennial habit; and pungency.

In spices, the region is known for variability in *Piper nigrum,* and in turmeric varieties like Megha turmeric-1 (earlier known as RCT-1) and ginger variety Nadia were found suitable for the region. Lakadong is a turmeric variety found in this region with high curcumin content (7.4%). A unique type of ginger having rhizomes with a bluish-black tinge inside, called black ginger, is grown by the inhabitants of Mizoram. Wild relatives of large cardamom and cinnamon are available in the forests of this region.

Among tropical fruits, the region harbors a significant amount of variability in the case of mango, with the dwarf and late-maturing polyembryonic type cultivar, Moresh, which bears sweet fruit with high pulp content and starts fruiting within 2 years from planting, and is free from stone weevil. Additionally, species like *Mangifera sylvatica* are also natural to the region. Being the home of several *Citrus* species, *Citrus indica, C. macroptera, C. aurantium,* and *C. reticulata,* the region presents rich genetic diversity (Bhattacharya and Dutta, 1956). The Indian wild orange *C. indica* is found in the Naga Hills, whereas, lemon (*C. limon*) is known with a large number of traditional cultivars, such as Hill lemon, Assam lemon, Nepali oblong, etc. In addition, a large number of other tropical and subtropical minor fruits belonging to the genera *Garcinia, Artocarpus, Phyllanthus, Annona, Averrhoa, Persea, Aegle, Passiflora,* etc. are found growing wild in the region. One of the indigenous fruits that require attention is jackfruit, which grows abundantly in Tripura.

Among temperate fruits, the locally available species, such as *Malus baccata* is widely

In vegetables, the region is part of the primary center of diversity for cucumber* (Cucumis sativus). *In addition, wild relatives of several cucurbits have also been reported from the region with significant genetic variability.

used as rootstock of apple, while *Pyrus pashia* is a common rootstock of pear. *Pyrus pyrifolia* is grown semi-commercially in Manipur and other places. Two species of silverberry, *Elaegnus latifolia* and *E. pyriformis*, are known to grow in this region and are edible and used for making a refreshing drink (Pandey, 2002). The fruits of *Docynia indica* and *D. hookeriana*, acidic, greenish with a red-tinge, are eaten fresh and used in pickles, as well as in jelly preparations.

The region is very rich in floristic diversity, particularly orchids, which may be used to promote floriculture. Some of the prized orchids occurring in this region are Red Vanda, Blue Vanda, Slipper orchids, and Jewel orchids. Further, the local communities of the region have generated rich knowledge about the medicinal value of a large number of indigenous plants. For example, Singh and Singh (2008) have listed around 100 plants with medicinal value from Manipur alone. This needs experimentation and laboratory testing for validation of the reported potential to facilitate promotion of their use on a greater scale and their integration in poverty alleviation programs.

Future perspective

Despite the availability of indigenous technologies for conservation of bioresources, the Northeastern Hill region is becoming increasingly deforested and denuded due to shifting cultivation and overexploitation of resources. Biotic and abiotic interferences have caused further degradation to natural resources such as soil, water, and forests, to the extent that the flow of rivers becomes destructive during the monsoon due to flooding, and due to insufficient water during dry seasons. Vegetation has a great effect on soil loss due to runoff. Therefore, soil conservation measures and afforestation need to be implemented immediately to control the damage caused by excessive runoff. This may help reverse the trend of declining rainfall in the last 10 years due to continuous deforestation.

There is rampant destruction of forestlands due to shifting cultivation (*jhum*), which is also causing a tremendous loss of species and agrobiodiversity. While the region is rich in species diversity, it is known for many alternative plant sources for food, fuel, forage, medicine, etc. Therefore, there is a need for a survey of under-utilized alternative sources of food plants, vegetables, fruits, spices, and medicinal species for their further evaluation, domestication, promotion, popularization, and marketing to facilitate regular use. This will help generate new avenues for the farmers to increase their income with cultivation of well-adopted diverse sources of economic value.

Among tropical fruits, the region harbors a significant amount of variability in the case of mango, with the dwarf and late-maturing polyembryonic type cultivar, Moresh, which bears sweet fruit with high pulp content and starts fruiting within 2 years from planting, and is free from stone weevil.

The soils of the region are highly acidic; forest production on acid soils that are poor in basic cations (Ca, Mg, K) is limited by mineral deficiencies. The sustained production of the forest ecosystem is closely linked to its nutrient cycle, particularly in the tropical regions where a greater percentage of nutrients are contained in the biomass. The burning of forest residues practiced during land clearing is leading to considerable nutrient loss from the ecosystem (Toky and Ramakrishna, 1981). Therefore, sustained forest productivity requires the use of techniques which reduce nutrient export, increase nutrient accumulation in the biomass, increase efficiency of nutrient absorption and utilization and conservation of water in the system. Despite the best efforts of the local people with innovative practices, only about 18% of the ultimate capacity for providing water to the land is being used. The irrigation potential is much larger than the achieved; therefore, greater research efforts are needed to improve the use of water resources. It may require refinement of indigenous knowledge adopted in the production systems on the basis of the latest know-how, with the participation of the local people for identifying the problems of resource degradation, and constraints and opportunities available for sustainable management of resources.

Soil conservation measures and afforestation need to be implemented immediately to control the damage caused by excessive runoff. This may help reverse the trend of declining rainfall in the last 10 years due to continuous deforestation.

Horticultural crops can generate substantial marketable surplus for which adequate processing facility is necessary for value-addition and commercial trading.

Despite being the rich horticultural biodiversity heritage site, favorable factors and the scope for cultivation of horticultural crops, horticulture has not gained the desired momentum in the region. Horticultural crops can generate substantial marketable surplus for which adequate processing facility is necessary for value-addition and commercial trading. Therefore, there is a need for creation of storage, processing, and marketing facilities. There is enough scope for increasing farm returns through value-addition, and by use of efficient postharvest management practices, processing, and storage of produce and products.

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