

Probable Agricultural Biodiversity Heritage Sites in India: IV. The Brahmaputra Valley Region

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Abstract

The Brahmaputra Valley region has a unique landscape, with the Brahmaputra River and other rivulets running between the parallel hill ranges. The valley gets flooded during the monsoons, which deposit a large amount of silt and debris on the riverbeds. The local communities have developed systems to take advantage of such situations by developing a unique farming system of rice cultivation that integrates fish culture. The region has contributed significantly to world agriculture with the domestication of tea and Muga silk, and evolution of significant amount of genetic diversity in major crops such as rice and jute. Diverse races, such as the Austrics, Mongolians, Dravidians and Aryans have played a significant role in developing the agriculture, the composite culture and civilization of the region. The present article discusses these features in some detail, and proposes the region to be another National Agricultural Biodiversity Heritage Site, based on six indices.

Introduction

The northeastern region of India can be physiographically divided into three distinct divisions – the Meghalaya Plateau, the Northeastern Hills, and the Brahmaputra Valley. These three regions may have similarities in many areas of agriculture, but they stand distinct in terms of their products and practices, which would have evolved through the sustainable use and conservation of the landscape and available bio-resources.

Almost entirely situated in the state of Assam, and with more than 70% of its workforce engaged in agriculture and allied

activities, the Brahmaputra Valley made one of the greatest contributions to world agriculture by discovering the cultivation of tea (Ukers, 1935). In addition, its unique sericulture (which yields the internationally acclaimed Muga silk), its traditional pisciculture, and the evolution of unique and significant genetic diversity in important crops such as rice and jute, qualify it to be another Probable Agricultural Biodiversity Heritage Site, based on the indices illustrated by Singh and Varaprasad (2008). The Valley produces some of the finest and expensive teas in the world, and has the indigenous species *Camellia assamica*

(Masters) Hung T.Chang. The Muga silk is produced from the indigenous *Antheraea assama* Westwood (moth; n = 15). Both species are geographically associated with the region. Also, the region has accepted and adopted crops from other cultures. For example, chili, introduced from Brazil by the Portuguese in 1585 (Sturtevant, 1885) has evolved useful genetic diversity for plant type, fruiting behavior, and pungency (Borgohain *et al.*, 2008).

The region's unique natural landscape consists of the Brahmaputra River and its tributaries. During the monsoon, it gets flooded, mainly because it receives heavy rainfall within a short time. In its early stage of maturity, it is a very active agent of erosion. The river waters collect a tremendous amount of silt and other debris, and raise the level of the riverbeds. Therefore, it becomes impossible for the main channel to cope with the vast volume of water received during the rains, and makes organized agriculture difficult. However, the local people have evolved innovative systems to overcome these constraints and to harnessing the desired output. The Austriacs, Mongolians, Dravidians, and Aryans who came to this land a long time ago, contributed to the composite culture of the region, enriching the legacy of culture and civilization.

Location and extent

The Brahmaputra Valley is the sentinel of northeastern India and the gateway to the northeastern states of the country. The State of Assam, which is predominantly made up of the Brahmaputra Valley, is

close to India's international borders with Bangladesh and Bhutan. The Brahmaputra Valley is basically situated between two parallel hill ranges – the eastern Himalayan ranges of Arunachal Pradesh and Bhutan in the north; and the northeastern hill ranges of Meghalaya, north Cachar, and Nagaland in the south. The valley can be divided into three regions: the *western* Brahmaputra Valley region, covering the districts of Goalpara and Kamrup; the *central* Brahmaputra Valley region, covering Darang and Nowgong districts; and the *eastern* Brahmaputra Valley region, covering the districts of Lakhimpur, Dibrugarh, and Sibsagar. Parts of the Jalpaiguri district of West Bengal also drain into the Brahmaputra through the Teesta River. Thus, the region is located with Bhutan and Arunachal Pradesh on the north; Manipur, Nagaland, and Arunachal Pradesh on the east; and Meghalaya, Tripura, and Mizoram on the south (Fig. 1). The agricultural biodiversity heritage of the region extends to the districts adjoining the Brahmaputra River, its tributaries, and the Barak Valley, such as Dhubri, Kokrajhar, Bongaigaon, Barpeta, Nalbari, Golaghat, Morigaon, Sonitpur, Jorhat, Dhemaji, and Tinsukia.

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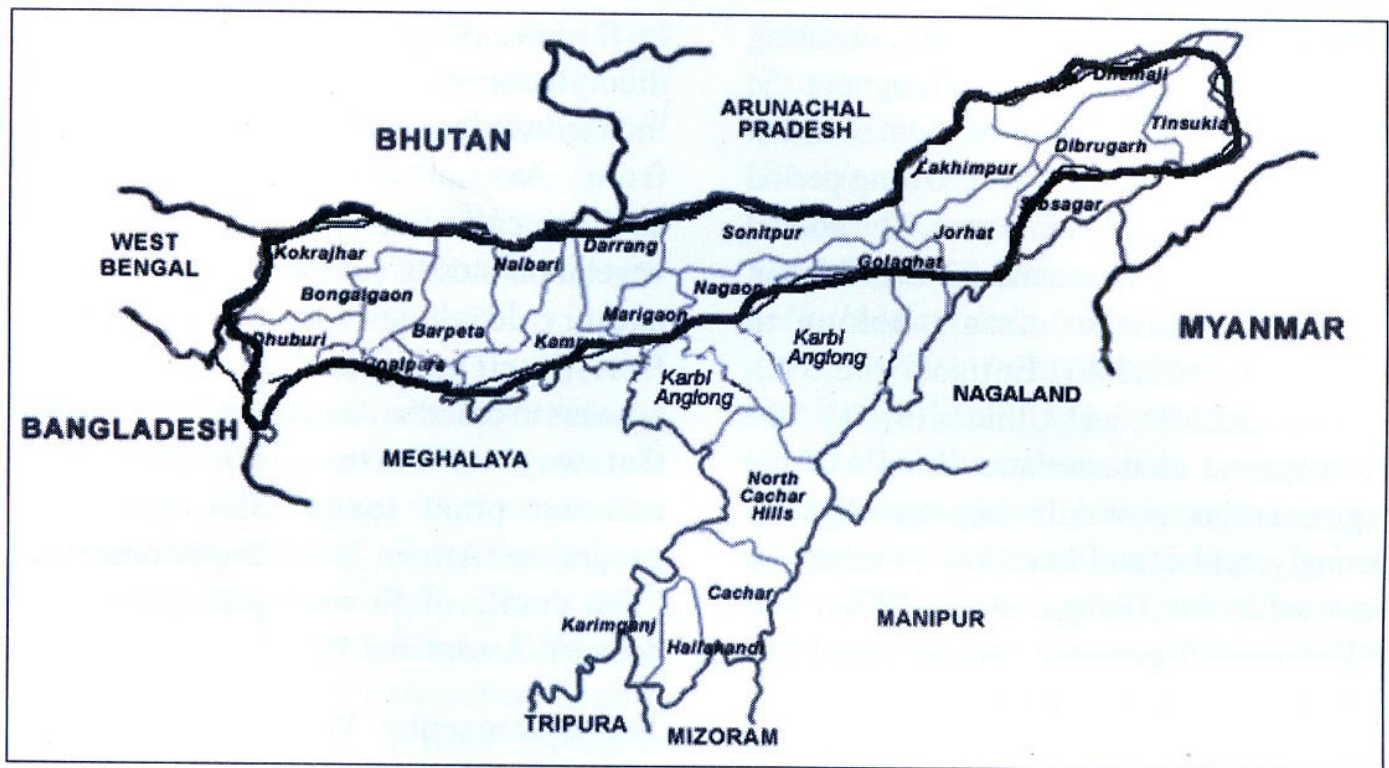


Figure 1. The Brahmaputra Valley region (map not to scale).

Landscape

The region has mountain slopes, rivers, coldwater streams; floodplain wetlands, reservoirs, lakes, and ponds. However, for the most part, it consists of the plains around the Brahmaputra and Barak rivers. A large part of Assam is located in the narrow valley that the river has created over the ages, making the state a scenic beauty, with gushing rivers on one side, snow-capped mountains on the other, and lush forests in between. The valley, which is a flat plain with alluvial land having a steady slope from its northeast corner Saidya to Dhubri in the west, is dominated by agricultural landscape with cultivation of a large number of indigenous crop species, such as rice and jute. The northern bank of the Brahmaputra is often inundated by the quick-flowing tributaries from the Arunachal Himalayas discharging into the Brahmaputra.

Agroclimate

The area is characterized by hot summers and mild to moderately cool winters. The mean annual rainfall ranges from 1,600 to 2,000 mm. The potential evapotranspiration

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ranges from 1,000 to 1,400 mm, ensuring the availability of moisture throughout the year, excepting for one or two months. Therefore, the length of the growing period is more than 270 days in a year. The annual soil temperature is around 22°C or higher. The major soils of Assam belong to Inceptisols (49.3%), Entisols (32.3%), Alfisols (12.3%), and Ultisols (6.1%). The most typical characteristic of soils of the region is that generally they are slight to strongly acidic, and have low to moderate base saturation (Sehgal *et al.*, 1992). The pH of the soils generally ranges from 4.2 to 5.8, with organic matter content of the majority of the soils between medium to high. The available N, P₂O₅, and K₂O content of the soils of Assam varies between medium and low.

Floristic diversity

Northeastern India is part of two global Biodiversity Hotspots – Himalaya and Indo-Burma (Mittermeier *et al.*, 2004). The Brahmaputra Valley falls between the two, and represents one of the areas where the northward-migrating Deccan Peninsula first made contact with the Eurasian continent during the early Tertiary Period; it therefore represents a gateway for species exchanges between the typically Indian and the Malayan faunas (Rodgers and Panwar, 1988) and also flora. The climatic conditions of the region cause prevalence of a hot and highly humid weather coupled with heterogenic physiography, making it suitable for the luxuriant growth of a number of plant communities, thereby imparting a distinct phytogeographic identity, with many endemic species. The region as a whole is very rich

in floristic diversity, with around 2,833 dicotyledonous angiosperms, and 1,072 monocotyledonous floral species recorded from Assam (<http://assamforest.in/environment/environment.php>). The natural vegetation mostly comprises tropical moist and dry deciduous forest. This array of floristic richness has prompted many scholars to describe Assam as the “Biological Gateway” of northeastern India. The eminent plant taxonomist and plant geographer Armen L Takhtajan observed, “The cradle of flowering plants lies in between Assam and Fiji.”

The Brahmaputra Valley – sandwiched between the eastern Himalaya in the north, and the Garo, Khasi, Jaintia and Mikir, Cachar, Barail hill ranges in the south – is a meeting ground of the temperate east Himalayan flora and the wet evergreen and wet deciduous floristic elements of Peninsular India. It is known for its rich forest wealth (22.21%). The *Revised Survey of Forest Types in India* by Champion and Seth (2005) categorized as many as 51 different forest types/subtypes for this region. The species diversity is so spectacular that it often becomes difficult to clearly assign separate niches to existing plant formations. The Brahmaputra Valley was naturally associated with Tropical Wet Evergreen Forests, Tropical Semi-Evergreen Forests, Tropical Moist Deciduous Forests, Littoral and Swamp Forests, and Grassland and Savannahs.

The *Tropical Wet Evergreen Forests* predominantly consists of hollong (*Dipterocarpus macrocarpus* Vesque), the

tallest tree of Assam and also the 'State Tree'. The other associated species are *borpat* (*Ailanthus grandis* Prain), *jutuli* (*Altingia exelsa* Noronha), *sam* (*Artocarpus chama* Buch.-Ham.), *dewa sam*, *nahar* (*Mesua ferrea* L.), *teeta champa* (*Michelia champaca* L.), *phelu* (*Tetrameles nudiflora* R.Br., rare), *mekai* (*Shorea assamica* Dyer), etc. Forests in the south had *garjan* (*Dipterocarpus terbinatus* C.F. Gaertn, rare) in association with *nahar* (*Mesua ferrea*), *bolong* [*Mesua floribunda* (Wall.) Kosterm.], *champa* (*Michelia glabra* P.Parm.), *kathalua* (*Palaquium polyanthum* Engl.), etc. The undergrowth in these forests is dense with low shrubs and herbs, canes, palms and bamboos growing along the edges of forests.

The **Tropical Semi-Evergreen Forests** have mostly medium-sized trees with a few large trees. Shrubs, lianas, climbers, orchids, and ferns grow copiously. At the fringe, bamboos and canes occupy the space. Species association and frequency of their occurrence vary from forest to forest, but the ones commonly found are *petarichawa* [*Actinodaphne obovata* (Nees) Blume], *ramanbih* (*Aesculus* L. spp.), *kadam/sam* (*Artocarpus chama*), *siris* (*Albizia Durazz.* spp.), *kadam* (*Anthocephalus chinensis* Hassk.), *khakan* (*Duabanga grandiflora*

Walp.), *hingori*, *dhobahingori* (*Castanopsis* (D.Don) Spach spp.), *outenga* (*Dillenia indica* L.), *kanchan* (*Bauhinia purpurea* L.), *jarul*, *ajar*, *sidha* (*Lagerstroemia* L. spp.), *phulsopa*, *gahorisopa*, *pansopa*, *kharikasopa*, *kathalsopa*, *duleesopa* (*Magnolia* L. spp.), *sinduri*, *joral*, *dudhloti*, *buritokan* (*Mallotus* Lour. spp.), *teeta champa* (*Michelia champaca* L.), *paharijam*, *mokrajam*, *berjamu*, *kolajamu*, *bogijamu*, *golapjamu* (*Syzygium* Gaertn. spp.), *bolem*, *ghugra* (*Schima wallichii* Choisy), *bhomora*, *bohera*, *harda*, *hilikha*, *hollok* (*Terminalia* L. spp.), *bhelkor* (*Trewia nudiflora* Wight), etc.

The **Moist Deciduous Forests** can be described as Sal Forests and Mixed Deciduous Forests. In these forests, sal (*Shorea assamica* Dyer) grows in association with *jarul*, *ajar* (*Lagerstroemia* L. spp.), *ghugra* (*Schima wallichii* Choisy), *paruli* [*Stereospermum personatum* (Hassk.) Chatterjee], *haldu* [*Adina cordifolia* (Roxb.) Brandis], *sam* (*Artocarpus* J.R.Forst. & G.Forst. spp.), *bor*, *dimoru*, *dhupbor*, *bot*, *athabor*, *tengabor*, *lotadioru*, *khongaldimoru* (*Ficus* L. spp.), *uriam* (*Bischofia javanica* Blume), *gomari* (*Gmelina arborea* Roxb.), *teeta champa* (*Michelia champaca*), *hilikha*, *bhomora*, *bohera* (*Terminalia* spp.), *poma* (*Toona ciliata* M.Roem.), etc. The Moist Deciduous Mixed Forests occur at the foot of the hills, with mostly deciduous trees having a sprinkling of a few evergreen and semi-evergreen species. The important plant species growing in these forests include *haldu* [*Adina cordifolia* (Roxb.) Brandis], *siris*, *kolasiris*, *koroi*, *sau* (*Albizia Durazz.*

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spp.), *satiana* (*Alstonia scholaris* (L.) R.Br.), *sam* (*Artocarpus chama*), *kumbhi* (*Careya arborea* Roxb.), *sissoo*, *medelua* (*Dalbergia* L.f. spp.), *bot*, *bor*, *dimoru* (*Ficus* spp.), *jarul*, *ajar* (*Lagerstroemia* L. spp.), *senduri*, *joral*, *dudhloti* (*Mallotus* Lour. spp.), etc. Bordering the Moist Deciduous Forests are rain shadow areas referred to as "Dry Forests" by Kanjilal *et al.* (1938). The important species in these forests include *bel* (*Aegle marmelos* Corrêa), *siris* (*Albizia* spp.), *sonaru* (*Cassia fistula* L.), *simul* (*Bombax* L.), *satiana* (*Alstonia scholaris*), *bor* (*Ficus* spp.), *loban*, *bagnola*, *mezankori*, *honwalu*, *digloti* (*Litsea* Lam. spp.), *neem* (*Melia azedarach* L.), *sajana* (*Moringa oleifera* Lam.), *bhatgila*, *senduri* (*Mallotus* spp.), *hilikha*, *bhomora* (*Terminalia* spp.), etc.

The *Littoral and Swamp Forests* have almost lost their identity because of biotic pressure, and sedges and grasses are now a component of the vegetation. The important species include *Ageratum*

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conyzoides L., *Alocasia* (Schott) G. Don spp., *Alpinia* L. spp., *Amaranthus* L. spp., *Bacopa* Aubl. spp., *Blumea* DC. spp., *Bombax* L. spp., *Crotalaria* L. spp., etc.

The *Grasslands and Savannahs* are dominated with biomass of grasses such as *Apluda mutica* L., *Phragmites karka* (Retz.) Steud., *Sclerostachya fusca* A. Camus, *Saccharum* L. spp., etc. (<http://assamforest.in/environment/environment.php>). Most of the above forest types have been converted into grasslands by centuries of forest fires and other human influences. Only small patches of forests now remain, scattered along the Indo-Bhutan border and along the border of Assam and Meghalaya. Many of these forest patches are confined to protected areas. To save the rich biodiversity, the region has 25 Protected Areas and several national parks and wildlife sanctuaries. The Kaziranga National Park, and the Nameri and Manas Tiger Project (National Park) are internationally famous for the one-horned rhino and Royal Bengal tiger, respectively.

Agriculture and agrobiodiversity

The valley is primarily an agricultural region, accounting for the livelihood of about four-fifths of the population of Assam. About 75% of the population is directly or indirectly dependent on agriculture, while about 69% of the workforce in the state is actually engaged in agricultural and allied activities. However, agriculture in the region had remained primitive for a long time. The implements used were archaic. Population scarcity and land abundance slowed down

the transition from traditional shifting hoe cultivation (*jhum*) to permanent plow cultivation, not only in the hills but also in the plains. Heavy plows drawn by several bullocks or seed drills were never used. Though most of the agriculture in the region is rainfed (270 days growing period), ponds called *Dongs* are constructed by the Bodo tribes to harvest water for irrigation during the lean period. These ponds are individually owned with no community involvement. In the Jalpaiguri district of West Bengal, *Dungs* or *Jampois* are small irrigation channels used for linking rice fields to streams.

Rice is the primary food crop; the cash crops grown are jute, tea, cotton, rapeseed, mustard, sugarcane, sweet potato, potato, etc. Also grown on a small scale are horticultural crops such as orange, banana, papaya, pineapple, areca-nut, coconut, guava, mango, jackfruit, vegetables, useful grasses, herbs, spices such as turmeric, etc. Being the primary or secondary center of diversity of several crop species, the region is home to a large number of varieties in crops such as rice, jute, cucumber, orange, etc.

The lowland valleys have rice fields; inundated flood plains have jute fields, while tea plantations are seen on the hill slopes. In the plains of the Brahmaputra Valley, more than half of the arable lands are under paddy cultivation. The area is intensely cultivated with rice. Among the other crops grown are maize, chickpea, pigeonpea, rapeseed-mustard, sesame, linseed, sugarcane, potato, tobacco, etc. Cultivation of indigo on a limited scale can be traced back to the eighteenth century. Jute is an

important commercial crop of the region. Sugarcane is claimed to be one of the main cash crops in the *kharif* (rainy) season. Some of the cropping patterns followed are: rice-rice, rice-rapeseed-mustard, rice-potato-sesame, rice-chickpea-lentil, rice-mung bean, and rice-black gram. Intercropping combinations of crops are toria + lentil, toria + chickpea, and maize + mung bean.

To overcome the excessive flooding during the monsoon and to take the advantage of the situation, the local farmers have developed an indigenous rice-fish farming system, where fish is harvested from rice fields as an additional crop (Fig. 2). This has been followed in this region since ancient times. This situation is very common in the lowland floodplain rice fields of the entire Brahmaputra Valley and Barak Valley. A fish crop is traditionally raised only from paddies of rainfed lowlands, both in shallow and deep water. In some places, irrigation-fed rice fields have also been adopted to include fish farming. Naturally occurring fishes and prawns enter the field during the monsoon and grow together with the rice crop. The deep water rice environment, where such practices are most common, cross more than 460,000 hectares in Assam (Das, 2002).

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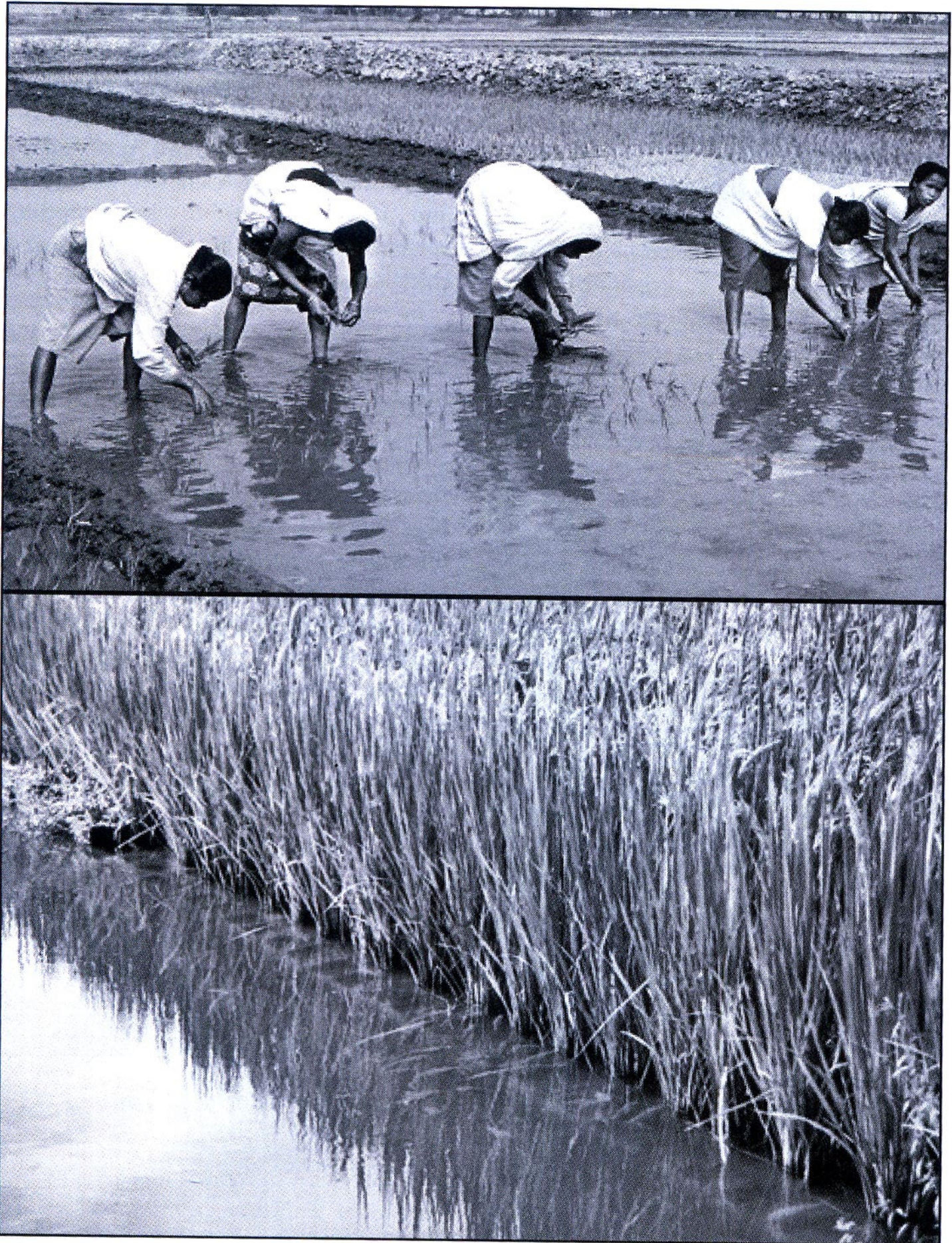


Figure 2. Cultivation of rice in Assam (top) and fish-rice farming (bottom) (see fish at the base of the rice plants).

The agroclimatic condition with high rainfall favors cultivation of a wide range of agri-horticultural crops. These include plantation crops, fruits, vegetables, flowers, spices, medicinal and aromatic plants, nuts, and tuber crops, grown under diverse farming systems, such as plantation, agroforestry, floriculture, home garden, etc. Tea is the main plantation crop, in addition to which, areca-nut and banana are other important plantation crops. Most horticulture products from the region are organic, as the use of chemical fertilizers is very low with the majority of the farmers still sticking to traditional organic farming methods.

With its vast hills and forests, the Brahmaputra Valley region is home to a variety of medicinal herbs and plants, such as *sarpagandha* (*Rauvolfia serpentina* Benth. ex. Kurz), *pippali* (*Piper longum* L.), *amlakhi* (*Emblca officinalis* Gaertn), *hilikha* (*Terminalia chebula* Retz.), *bhomora* (*Terminalia bellirica*), and arjun [*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.]. About 952 plant species of medicinal value are known to exist in Assam, with the Brahmaputra Valley itself having

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150 varieties of herbs and plants of commercial value. The region also has a vast array of aromatic plants. At present, most of the essential oils extracted are sold in crude form. Some of the plant species yielding essential oil are citronella [*Cymbopogon flexuosus* (Nees ex Steud.) Will. Watson], lemon-grass, patchouli (*Pogostemon cablin* Benth.), agarwood (*Aquilaria agallocha* Roxb.), etc. It is estimated that only about 5–10% of the plants and herbs are currently utilized and a large number with vast potential are yet to be explored and investigated.

The region's biggest contribution to world agriculture is tea. Most tea is being produced from the indigenous species *Camellia assamica*. After the discovery of *Camellia sinensis* Kuntze in Assam (1834), followed by its tests in 1836–37 in London, the British allowed companies to rent land for tea plantation since 1839. Thereafter, tea plantations mushroomed on the Upper Assam hill slopes (Fig. 3), where the soil and the climate were most suitable. Problems with imported laborers from China and hostilities of the native Assamese resulted in the migration of forced laborers from the central-eastern parts of India. After initial trial and error

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Figure 3. Tea plantation on hill slopes.

with planting the Chinese and the Assamese-Chinese hybrid varieties, the planters accepted the local *Camellia assamica* as the most suitable one. By the 1850s, the industry started seeing some profits. The industry saw initial growth, when in 1861, investors were allowed to own land in Assam and it saw substantial progress with invention of new technologies and machinery for preparing processed tea during the 1870s. The cost of Assam tea was lowered manifold and became more competitive than its Chinese variant. Despite the commercial

success, tea laborers continued to be exploited, working and living under poor conditions. Fearful of greater government interference, the tea growers formed The Indian Tea Association in 1888 to lobby to retain the status quo. The organization was very successful in this; consequently, even after India's independence, the conditions of the laborers have improved very little. Tea plantation on the slopes is an important production system, which was taken up not only in the upper reaches of the region, but also spread to the upper reaches of all the hills across the country.

Floriculture is another prevalent farming system, as Assam has over 600 varieties of orchids. Around 200 varieties are unique to this region, of which 60% are ornamental in nature, offering tremendous opportunities to

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the local farmers for increasing their income through floriculture.

In addition to the above farming systems, the climate and general environment of the region is well suited for sericulture to produce some of the best quality silk. The silkworm *Antheraea assama* is confined to only the Brahmaputra Valley of India. It produces the famous Muga silk. *Antheraea assama* are raised outdoors primarily on two trees – *som* (*Machilus bombycina* King ex Hook.f.) and *soalu* (*Litsaea polyantha* Juss.) (Fig. 4). Eri silk, on the other hand, is the product of the domesticated silkworm *Philosamia rinini* that feeds mainly on castor leaves. Eri-culture is a household activity practiced mainly for the protein-rich pupae, a delicacy for the tribals. The word 'Eri' is derived from the Sanskrit name for the castor plant, *eranada*. Castor leaves constitute the main food for the silkworms, hence the name Eri-silkworm. Eri is the only completely domesticated non-mulberry silkworm in India. Its silk is spun as

it cannot be reeled. Under traditional sericulture, farmers cultivate *som*, *soalu*, and castor bean for rearing silkworms on their aromatic leaves. Silkworm rearing has helped the local people in generating income, creating self-employment, and manpower harnessing. Traditional varieties of silk cultured include Eri, Muga, and mulberry. The Muga silk is known for its fine sheen and golden color. It is used by the local silk weaving industry and has contributed to the development of the Muga culture in the State. The region offers vast opportunities in silk processing and spinning units.

Fish is an important constituent of the diet of about 95% of Assam's population. The rivers, coldwater streams, floodplain wetlands, reservoirs, lakes, ponds, paddy fields, and mini-barrages of the region support large-scale aquaculture activities, which can not only produce fish to meet the regional requirements, but also leave a surplus for export. The captured fish from



Figures 4. Plantation of *som* (*Machilus bombycina*) and *soalu* (*Litsaea polyantha*) trees (left), and Muga worms transforming into cocoons (right).

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the Brahmaputra River, Barak River, and Beel fisheries contribute about 80.6% of the total production, but this is fast declining due to overexploitation and indiscriminate fishing.

The farming system of *Nageswari* ducks is another unique feature of the region (Zaman *et al.*, 2005). This important egg-type native variety of duck was found only in a few areas of the Cachar and Karimganj districts of the Barak Valley zone. The representative plant species that are part of the large- or marginal-scale farming in the region are given below.

Representative plant species in various crop groups

Cereals, pseudocereals, and millets.

Finger millet (*Eleusine coracana* Gaertn.), foxtail millet [*Setaria italica* (L.) P.Beauv.], maize (*Zea mays* L.), rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), grain amaranth (*Amaranthus* spp.).

Grain legumes and oilseeds.

Asparagus bean [*Vigna unguiculata* (L.) Walp. subsp. *Sesquipedalis* (L.) Bertoni], black gram [*Vigna mungo* (L.) Hepper], chickpea (*Cicer arietinum* L.), cowpea [*Vigna vexillata* (L.) A.Rich., syn. *V.*

capensis], Jerusalem artichoke (*Helianthus tuberosus* L.), lentil (*Lens culinaris* Medik.), linseed (*Linum usitatissimum* L.), mustard [*Brassica juncea* (L.) Czern.], pigeonpea [*Cajanus cajan* (L.) Millsp.], rice bean [*Vigna umbellata* (Thunb.) Ohwi & H. Ohashi], sesame (*Sesamum indicum* L.), toria (*Brassica rapa* L. var. *toria*).

Fibers and fodder. China grass [*Boehmeria macrophylla* Siebold & Zucc., *B. nivea* (L.) Gaudich.], Nepal hemp (*Maoutia puya* Wedd.), *Digitaria cruciata* Nees, *Stylosanthes guianensis* (Abul.) Sw., *jangali dhan* (*Leersia hexandra* Sw.), jute (*Corchorus olitorius* L.), *khunju* (*Lespedeza cuneata* G. Don.), Marida hemp (*Musa textilis* Nee), mesta, (*Hibiscus sabdariffa* L.), white jute (*Corchorus capsularis* L.).

Vegetables. Bell pepper (*Capsicum annum* L.), *bhat karela* (*Momordica dioica* Wall.), *bhut jolokia* (*Capsicum annum* Chinese Group, 'Naga jolokia'), bitter melon (*Momordica charantia* L.), bottle gourd [*Lagenaria siceraria* (Molina) Standl.], brinjal or eggplant (*Solanum melongena* L.), carrot (*Daucus carota* L.), cucumber (*Cucumis sativus* L.), curry banana (*Musa splendida* A.Chev.), ivy gourd [*Coccinia grandis* (L.) Voigt]; leafy vegetables – spinach (*Spinacia oleracea* L.), water spinach (*Ipomoea aquatica* Forssk.), mustard greens [*Brassica juncea* (L.) Czern.], green amaranth (*Amaranthus viridis* L.), Indian spinach (*Basella rubra* L.), sorrel (*Rumex acetosa* L.), *jilmil* (*Chenopodium album* L.), *bhringraj* (*Eclipta alba* L. ex B.D.Jacks.), *methi*

xaak (*Trigonella foenum-graecum* L.), okra (*Abelmoschus esculentus* Moench), *olkobi* (*Brassica oleracea* var. *botrytis* L., *B. oleracea* var. *viridis* Gongylodes Group), onion (*Allium cepa* L.), pea (*Pisum sativum* L.), *phulkobi* [*Brassica oleracea* var. *capitata* (L.) DC.], pointed gourd (*Trichosanthes dioica* Roxb.), potato (*Solanum tuberosum*), pumpkin or squash (*Cucurbita pepo* L.), radish (*Raphanus sativus* L.), snake gourd (*Trichosanthes anguina* L.), sponge gourd (*Luffa aegyptiaca* Mill., syn. *L. cylindrica* M.Roem.), sweet gourd [*Momordica cochinchinensis* (Lour.) Spreng.], turnip (*Brassica rapa* L. var. *rapa*).

Tubers. Beet (*Beta vulgaris* L.), elephant-foot yam [*Amorphophallus bulbifer* (Roxb.) Blume var. *bulbifer*, *A. bulbifer* var. *tuberculiger*], sweet potato [*Ipomoea batatas* (L.) Poir.], taro [*Colocasia esculenta* (L.) Schott], white yam (*Dioscorea alata* L., *D. bulbifera* L., *D. hispida* Dennst., *D. pentaphylla* L. var. *kussok*, *D. prazeri* Prain & Burkill, *D. trinervia* Roxb. ex Prain & Burkill), and yam bean [*Pachyrhizus erosus* (L.) Urb.].

Spices. Aniseed (*Pimpinella anisum* L.), Bengal cardamom (*Ammomum aromaticum* Roxb.), betel-nut or areca-nut (*Areca catechu* L., *A. triandra* Roxb. ex Buch-Ham), black cumin (*Nigella sativa* L.), black pepper (*Piper nigrum* L.), cardamom (*Elettaria cardamomum* Maton), cinnamon or *tejpat* (*Cinnamomum tamala* T.Nees & Eberm.), clove [*Syzygium aromaticum* (L.) Merr. & L.M.Perry], *dalseni* (*Cinnamomum verum* J.Presl), galangal (*Alpinia malaccensis* C. Presl), garlic

(*Allium sativum* L.), ginger [*Zingiber officinale*, *Z. zerumbet* (L.) Roscoe ex J.E. Smith, *Z. capitatum* Roxb.], lemon-grass [*Cymbopogon jawarancusa* (Jones) Schult. var. *assamensis*], mango ginger (*Curcuma amada* Roxb.), turmeric (*Curcuma longa* L., syn. *C. domestica* Valet), *jungali-memedo*, *bhandhanya* (*Eryngium foetidum* Walter), white mustard (*Sinapis alba* L.).

Fruits. Assam lemon [*Citrus limon* (L.) Burm.f.], banana (*Musa acuminata* L.), date palm (*Phoenix dactylifera* L.), fig (*Ficus carica* L., *F. pomifera*), ginger citrus (*Citrus assamensis* S.Dutta & S.C.Bhattacharya), Himalayan bird cherry [*Prunus cornuta* (Wall ex Royle) Steud.], jackfruit (*Artocarpus heterophyllus* Lam.), khasi mandarin (*Citrus reticulata* Blanco), mango (*Mangifera indica* L.), papaya (*Carica papaya* L.), pineapple [*Ananas comosus* (L.) Merr.], plantain (*Musa sapientum* L.), pomelo [*Citrus maxima* (Burm.) Merr.].

Beverages, plantation, and other crops. Areca-nut (*Areca catechu* L.), coconut (*Cocos nucifera* L.), sugarcane (*Saccharum officinarum*), tea (*Camellia assamica*, also sometimes considered as *C. sinensis* var. *assamica*).

Other economic plants

Minor fruits. Banana (*Musa* spp.), *Drypetes assamica* (Hook.f.) Pax & K.Hoffm., elephant apple (*Dillenia indica*), coffee plum or *paniala* [*Flacourtia jangomas* (Lour.) Raeusch.], *kathaphal* (*Baccaurea ramiflora* Lour.), mangosteen (*Garcinia hombroniana* Pierre,

G. pedunculata Roxb. ex Buch.-Ham., *G. sopsopia* (Buch.-Ham.) Mabb., *G. stipulata* T. Anderson, *G. xanthochymus* Hook.f.), monkey jack (*Artocarpus lakoocha* Roxb.), myrobalan (*Terminalia chebula* Retz.), *rudraksh* (*Elaeocarpus floribundus* Blume), sausage vine (*Holboellia latifolia* Wall.).

Minor vegetables. Bamboo (*Dendrocalamus hamiltonii* Nees and Arn. ex Murno), *bhringraj* (*Eclipta alba*), *Cissus repens* A.Chev. (leaves), *manimuni* [*Centella asiatica* (L.) Urb.], *meello karela* (*Cyclanthera pedata* Schrad.), *piyanj xaak* (*Allium cepa* Proliferum Group), runner bean (*Phaseolus coccineus*).

Medicinal plants. Altogether, 150 plant species have been identified, which have been used in medical practices in some or other form, such as ginger [*Zingiber officinale* Roscoe, *Z. zerumbet* (L.) Roscoe ex J.E.Smith], agarwood (*Aquillaria malaccensis*), *amla* (*Embllica officinalis* Gaertn.), *asoka* (*Saraca indica* L.), *banhaldi* (*Curcuma aromatica* Salisb.), cane (*Canarium strictum* L.), *chalmugra* (*Hydnocarpus kurzii* Warb.), *Costus speciosus* Sm., *dudhkuri* [*Holarrhena antidysenterica* (L.) Wall.], greater galangal [*Alpinia galanga* (L.) Sw.], *Gynocardia odorata* R.Br., *hilikha*, *bahera* (*Terminalia* species), *loha-jam* (*Eugenia jambolana* Lam.), *mahabhringraj* [*Wedelia calendulacea* (L.) Less.], *mejankuri* (*Litsea cubeba* Pers.), *Mucuna pruriens* (L.) DC., *nux-vomica* (*Strychnos nux-vomica* L.), *pipoli* (*Piper longum* Blume), *satmul* (*Asparagus racemosus* Willd.), *Solanum khasianum* C.B.Clarke (syn. *S.*

aculeatissimum Jacq.), sweet flag, *bach* (*Acorus calamus* L.), *thekera* (*Garcinia* spp.), *titaphul* [*Phlogacanthus thyrsiflorus* (Roxb.) Nees], and *tulsi* (*Ocimum* L. spp.) (<http://assamforest.in/environment/environment.php>). In addition, some of the plants used by the Sonowal Kacharis tribe for medicinal purposes include *Allium sativum* L., *Oryza sativa*, *Senna sophora* (L.) Roxb. (syn. *Cassia sophora* L.), *Ricinus communis* L., and *Ananas comosus* (L.) Merr. Studies were conducted during 2000–02 to identify the wild and domesticated plants used by members of the Sonowal Kacharis tribe of the Brahmaputra Valley; they revealed that a total of 42 plants are traditionally used by the people of this tribe, including 35 dicotyledons, 5 monocotyledons, and one fern (Kalita and Deb, 2006).

Timber. *Bara mahogany* (*Swietenia macrophylla* King, introduced), bastard's teak (*Callicarpa macrophylla* Vahl.), chir pine (*Pinus roxburghii* Sarg.), hollock (*Terminalia myriocarpa* Van Heurck & Müll.Arg.), hollong (*Dipterocarpus macrocarpus*), *kadam* (*Artocarpus chama*), *nahar* (*Mesua ferrea*), oak (*Quercus acutissima* Carruthers, *Q. lamellosea* Sm.), rosewood (*Dalbergia wattii* C.B.Clarke, Manipur), sal (*Shorea assamica*), *Schima indica*, spindle tree (*Euonymus assamicus* Blakelock).

Bamboos and canes. Altogether 38 naturally growing species of bamboo are recorded in Assam, of which the common ones are *bhaluka* bamboo (*Bambusa balcooa* Roxb.), *makal*/bamboo (*Bambusa pallida* Munro, *B. cacharensis* R.Majumdar), *bijili/jati* bamboo (*Bambusa*

tulda Roxb.), *kakua*/bamboo (*Dendrocalamus hamiltonii* Nees & Arn. ex Munro), *katabans*/iron bamboo (*Dendrocalamus strictus* Nees), *mokalm* bamboo (*Dendrocalamus giganteus* Munro), and *muli* bamboo (*Melocanna bambusoides* Trin., *M. baccifera* Skeels). Fourteen species of cane grow in the forests of Assam, and *Calamus flagellum* Griff. ex Mart., *C. floribundus* Griff., and *C. latifolius* Kurz are found widely distributed throughout the state.

Ornamentals. The region is very rich in orchids; around 600 varieties are reported, some common orchids being *Dendrobium aurantiacum* Reichb.f., *Eulophia kamarupa* Sud. Chowdhury, etc. In addition, the following other species are cultivated: butterfly/ginger lily (*Hedychium coronarium* J.Koenig, *H. radiatum* A.S.Rao & Hajra, *H. robustum* A.S.Rao & Hajra), *Chrysoglossum assamiacum* Reichb.f., jasmine (*Jasminum attenuatum* Roxb. & G.Don, *J. azoricum* Heyne ex Wall.), champa (*Michelia champaca* L.), *Miscanthus* spp., *Phoenix rupicola* T.Anderson, etc.

Multipurpose species. *Calamus tenuis* Roxb. (medicinal, cane), date palm (*Phoenix dactylifera* L.), *kapur kachri* (*Hedychium spicatum* Lodd., ornamental and medicinal), *korial/zongta* [*Parkia timoriana* (DC.) Merr., syn. *P. roxburghii* G.Don.], *Zanthoxylum rhetsa* DC., etc.

Wild relatives of cultivated plants

Brassica trilocularis Hook.f. & Thom., *Camellia kissi* Wall., *Cinnamomum bejolghota* (Buch.-Ham.) Sweet (syn. *C.*

obtusifolium Roxb. ex Nees), *C. glanduliferum* (Wall.) Meisn., *C. paniculatum*, *C. pauciflorum* Chun ex H.T.Chang, *Citrus assamensis* S.Dutta & S.C.Bhattacharya, *C. indica* Tanaka, *Coffea bengalensis* Roxb., *C. fragrans* Wall. ex Hook.f., *Colocasia fallax* Schott, *C. mannii* Hook.f., *Cucumis hystrix* Chakrav., *C. trigonus* Roxb., *Curcuma amada* Roxb., *C. aromatica* Salisb., *Dioscorea hamiltonii* Hook.f., *D. sinensis* var. *assamica*, *D. trinervia* Roxb. ex Prain & Burkill, *Echinochloa crusgalli* (L.) P.Beauv., *Elaeocarpus floribundus* Blume, *Eleusine indica* Steud., *Erianthus filifolius* (Steud.) Nees ex Hack. (syn. *Saccharum filifolium* Steud.), *E. ravennae* (L.) P.Beauv., *Euonymus assamicus* Blakelock, (spindle tree), *E. vagans* Wall., *Garcinia keeniana*, *G. lanceaefolia* Roxb., *Luffa graveolens* Roxb., *Mangifera sylvatica* Roxb., *Miscanthus nudipes* (Griseb.) Hack., *Miscanthus wardii* Bor, *Momordica macrophylla* Gage, *Musa assamica* G.Mann. ex Baker, *M. cheesmanii* N.W.Simmonds, *M. flaviflora* Simmonds, syn. *M. thomsoni* King ex Cowan, *M. itinerus* Cheesman, *M. mannii* H.Wendl. ex Baker, *M. paradisiaca* L., *M. superba* Roxb., *M. velutina* H.Wendl. & Drude, *Narenga fallax* (Balansa) Bor, *Oryza rufipogon* Griff., *O. sativa* L. var. *spontanea*, syn. *O. perennis* Moench, *Phoenix rupicola* T. Anderson, *Piper peepuloides* Roxb., *Polytoca wallichiana* (Nees) Benth., *Prunus cerasioides* D.Don., *P. jenkinsii* Hook.f., *P. nepalense*, *Rubus moluccanus* L., *Saccharum longisetosum* Nayaran. ex Bor, *S. rufipilum* Steud., *S. wardii* (Bor) Bor ex Cope, *Solanum*

kurzii Brace ex Prain, *S. nigrum* L., *Syzygium assamicum* (Biswas & Purkayastha) Raizada, *Trichosanthes bracteata* Voigt, *T. cordata* Wall., *Vigna clarkei* Prain, *V. trilobata* (L.) Verdc., *Zingiber intermedium* Baker, *Z. rubens* Roxb., *Z. spectabilis* Griff. Bor. (Arora and Nayar, 1984).

Endemic species

Acacia diadenia R.Parker, *Bambusa cacharensis* R.B.Majumdar, *Camellia assamica* [syn. *C. sinensis* (L.) Kuntze var. *assamica* (Masters) Kitamura], *Chrysoglossum assamicum* Hook.f., *Cinnamomum cacharensis* Parker, *Citrus assamensis* S.Dutta & S.C.Bhattacharya, *Cymbopogon jwarancusa* (Jones) Schult. var. *assamensis*, *Dendrobium assamicum* Sud.Chowdhury, *D. aurantiacum* Rchb.f., *Dendrocalamus patellaris* Gamble, *Dioscorea pentaphylla* L. var. *kussok* Prain, *Euonymus assamicus* Blakelock, *E. vagans* Wall., *Fissitigma santapau* D.Das (fruit edible), *Garcinia keeniana* Pierre, *G. lanceaefolia* Roxb., *Gigantochloa macrostachya* Kurz, *Glycosmis singuliflora* Kurz, *Heritiera dubia* Wall., *Ixora goalparensis* Bremek., *Magnolia caveana* (Hook.f. & Thomson) D.C.S.Raju & M.P.Nayar, *M. gustavii* King, *Michelia mannii* King, *Musa assamica* Bull. ex Baker, *M. velutina* Wendl & Dryde, *Ormosia assamica* Yakovlev, *Pandanus assamensis* H.St.John, *Phyllostachys assamica* Gamble, *Piper clarkei* C.DC., *P. jenkinsii* C.DC., *Saccharum wardii* Bor, *Syzygium assamicum* (Biswas & Purkayastha) Raizada, *S. cyanophyllum* (P.C.Kanjilal &

Das) Raizada, *Zingiber intermedium* Baker, *Z. rubens* Roxb., *Z. spectabilis* Griff. (Nayar, 1996). Additionally, *Adiantum assamicum* B.K.Nayar in B.K.Nayar & Kaur, *Alseodaphne andersonii* (King ex Hook.f.) Kosterm., *Alseodaphne khasyana* (Meisn.) Kosterm., *Angiopteris assamica* de Vriese, *Coelogyne assamica* Linden & Rchb.f., *Combretum wallichii* Kurz, *Dinochloa indica* (R.B.Majumdar) U.Shukla & C.R.Das, *Diospyros cacharensis* (Das & P.C.Kanjilal) H.B.Naithani, *Dipterocarpus mannii* King ex U.N.Kanj., P.C.Kanjilal & Das, *Eugenia cyanophylla* P.C.Kanjilal & Das; bamboos like *Bambusa jaintiana* R.B.Majumdar, *B. mastersii* Munro, and orchids such as *Bulbophyllum elassonotum* Summerh. have been recorded endemic in the report produced by the Department of Environment and Forests, Government of Assam (<http://assamforest.in/environment/environment.php>). Table 1 lists some of the agriculturally important plant species endemic to the region.

Threatened species

Bambusa mastersii Munro, *Cleisostoma arietinum* (Rchb.f) Garay, *Cyperus corymbosus* (L.) Rottb., *Dendrobium assamicum* Sud. Chowdhury, *D. aurantiacum* Rchb.f., *Magnolia gustavii* King, *Hetaeria anomala* Lindl., *Liparis stachyurus* Rchb.f., *Paphiopedilum spicereanum* (Rchb.f. ex Masters & T.Moore) Pfitz., *P. insigne* Pfitzer, *P. venustum* Pfitzer, *P. villosum* Pfitzer, *Sapria himalayana* Griff. are reported to be extinct

Table 1. Representative agriculturally important species endemic to Assam, part of the Probable Agricultural Biodiversity Heritage Site (Brahmaputra Valley: Assam and parts of West Bengal).¹

Species	Family	Habit	Distribution	Remarks/Use
<i>Bambusa cacharensis</i>	Poaceae		Assam	Furniture
<i>Camellia sinensis</i> var. <i>assamica</i>	Theaceae	Shrub	Assam	Wild relative
<i>Citrus assamensis</i>	Rutaceae	Shrub	Assam	Wild relative
<i>Cymbopogon jwarancusa</i> var. <i>assamensis</i>	Poaceae	Herb	Assam	Essential oil
<i>Dendrobium aurantiacum</i>	Orchidaceae	Shrub	Assam	Ornamental
<i>Dendrocalamus patellaris</i>	Poaceae	Tall culm	Assam	Multipurpose, bamboo
<i>Dioscorea pentaphylla</i> var. <i>kussok</i>	Dioscoreaceae	Tuberous climber	Assam	Medicinal
<i>Dipterocarpus macrocarpus</i>	Dipterocarpaceae	Tall tree	Assam	Timber; 45–50 m tall
<i>Eulophia kamarupa</i>	Orchidaceae	Herb	Assam	Ornamental, medicinal
<i>Euonymus assamicus</i>	Celastraceae	Small tree	Assam	Medicinal, wood
<i>Ixora goalparensis</i>	Rubiaceae	Shrub	Assam	Ornamental, medicinal
<i>Magnolia caveana</i>	Magnoliaceae	Large tree	Assam	Ornamental
<i>Magnolia gustavii</i>	Magnoliaceae	Tree	Assam	Large flowers; 20–30 m tall
<i>Michelia mannii</i>	Magnoliaceae	Tree	Assam	Ornamental
<i>Musa assamica</i>	Musaceae	Perennial herb	Assam	Wild relative
<i>Musa velutina</i>	Musaceae	Perennial herb	Assam	Wild relative
<i>Phyllostachys assamica</i>	Poaceae	Shrub	Assam	Walking sticks
<i>Saccharum wardii</i>	Poaceae	Tall herb	Assam	Wild relative
<i>Zingiber intermedium</i>	Zingiberaceae	Herb	Assam	Wild relative

1. Source: Nayar (1996); <http://assamforest.in/environment/environment.php>; and others.

in the wild. Besides the above, 284 species of plants are observed to be critically endangered, 149 species as endangered, 58 species as vulnerable, and 13 species as near threatened (<http://assamforest.in/environment/environment.php>). Table 2 lists some of the agriculturally important plant species under threat.

Associated culture and tribes

The region is predominantly inhabited by Indo-Mongoloids, Indo-Aryans, and Austriacs. The Austriacs, Mongolians, Dravidians, and Aryans who came to this land a long time ago have contributed to the composite culture of the region, which has

Table 2. Representative agriculturally important species under threat in the Probable Agricultural Biodiversity Heritage Site (Brahmaputra Valley: Assam and parts of West Bengal).¹

Species	Family	Habit	Threat level ²	Remarks/Use
<i>Bambusa mastersii</i>	Gramineae	Climber	R	Climbing bamboo
<i>Cleisostoma arietinum</i>	Orchidaceae	Herb	EX	Orchid
<i>Cyperus corymbosus</i>	Cyperaceae	Herb	EX	Match sticks and reeds
<i>Dendrobium assamicum</i>	Orchidaceae	Herb	EX	Orchid
<i>Dendrobium aurantiacum</i>	Orchidaceae	Herb	R, VU	Epiphyte, ornamental
<i>Magnolia gustavii</i>	Magnoliaceae	Tree	VU	Horticulture and other purposes
<i>Hetaeria anomala</i>	Orchidaceae	Herb	EX	Ornamental
<i>Paphiopedilum spicereanum</i>	Orchidaceae	Herb	EX	Orchid
<i>Paphiopedilum insigne</i>	Orchidaceae	Herb	CR	Ornamental
<i>Paphiopedilum venustum</i>	Orchidaceae	Herb	CR	Ornamental
<i>Paphiopedilum villosum</i>	Orchidaceae	Herb	CR	Orchid
<i>Sapria himalayana</i>	Rafflesiaceae	Herb	EX	Largest leafless root parasitic plant

1. Source: <http://assamforest.in/environment/environment.php>; and others.

2. CR = Critically endangered; EX = Possibly extinct from the wild; R = Rare; VU = Vulnerable.

resulted in a rich legacy of diverse culture and civilization. The Bhutia and Bodo are the main tribes associated with agriculture. Very early on, the Bodos probably introduced rice cultivation, tea plantation, pig and poultry farming, and silkworm rearing in northeastern India. The Bodo tribal community is very fond of the conventional drink called *Zu mai*, where *Zu* means wine, *mai* means rice. Rice is the staple, and is often accompanied by fish or pork.

Weaving is another integral component of Bodo culture. Many families rear their own silkworms; the cocoons are spun into silk. Bodo girls learn to weave from a young age, and no Bodo courtyard is complete without a loom. Most women weave their own *Dokhnas* (the traditional dress of the Bodo women) and shawls.

The Bodos are also expert craftsmen in bamboo products. Singphow is another powerful tribe living in the plains and hills of Assam, and traces its origins from Singra-Boom in Tibet.

Historically, the Assam region was a major exporter of key agricultural and forest-produced commodities to the neighboring areas. Even two centuries ago, it was known for its raw cotton, lac, mustard seeds, Muga silk cloth, Muga silk thread, elephant tusks, bell metal, utensils, iron hoes, pepper and miscellaneous forest produce. Earlier the trade balance was always in deficit, because of the pricing value of these natural, agricultural, and craft products; however, it has improved in the recent past and has gone into surplus.

Technology and products

The Brahmaputra Valley region is part of primary and secondary centers of diversity of several commercially important crops such as rice, jute, cucumber and several other cucurbitaceous vegetables, banana, citrus, mango, tea, etc. It has evolved into a reservoir of rich genetic diversity for major crops such as rice and jute, and for several vegetable crops due to its diverse topography, tectonic intervention, land slips, heavy rainfall (which causes flooding and inundation), and selection pressures applied by the local people. The intense cultivation of rice and jute, and the identification of elite species and varieties by farmers through selection, has resulted in the domestication and evolution of high-yielding strains. This has also resulted in the development of a large number of landraces and cultivars in major crops, with a very wide spectrum of variability for different traits. For example, more than 6,600 distinct accessions of rice have been collected from this region (Koo *et al.*, 2004). They are generally referred as the Assam Rice Collection, because of the significant genetic variability in Assam rice cultigens. These collections include

disease-resistant landraces, flood-tolerant or submergence-tolerant and better cooking quality rice varieties.

The region offers a variety of ecosystems and cultivation in major crops from centuries. This has resulted in the evolution of a large number of landraces and traditional varieties, with variability for different traits, for example in rice, for resistance/tolerance to stem borer, Tungro virus, and drought, deep-water floating, waxy endosperm, scent, soft cooking, etc. As per Siddiq *et al.* (2006), these collections have variability in the form of resistance to almost all insect pests and diseases of rice, which is being used in resistance breeding throughout the world. These collections include landraces, referred as boiled rice or soft cooking rice (cooked at 60°C water temperature), waxy endosperm type, submergence-tolerance type, etc.

Among grain legumes, the region is known for variability in rice bean, particularly for early maturity. In the case of oilseeds, significant variability has been recorded for Indian mustard, particularly in the case of *Brassica rapa* var. *toria*, where the local landraces have contributed to the development of several varieties such as M2, M3, M27, M18, and TS29 (early maturing) from a landrace collected from Nagaon, Assam (Kumar *et al.*, 2004). In the case of castor, the region is known for the purple morpho-type with all purple parts and resistance to leaf miner.

In the case of cotton, the area is known for variability in *Gossypium arboreum* race *cernuum*. In the case of jute and mesta,

The region is predominantly inhabited by Indo-Mongoloids, Indo-Aryans, and Austrics. The Austrics, Mongolians, Dravidians, and Aryans who came to this land a long time ago have contributed to the composite culture of the region, which has resulted in a rich legacy of diverse culture and civilization.

Hibiscus sabdariffa L., the region is known for multiple-branched genotypes (Saha *et al.*, 2004).

In vegetable crop species, the continuum of variability extending to this region is known for variability in *Solanum melongena* for fruit shape, size, and color (Kalloo *et al.*, 2005). Similar variability has been observed in okra both for five-edged and multi-edged types. Additionally, *Abelmoschus pungens* Wall. distribution extends to this region. Welsh onion (*Allium fistulosum* L.) cultivated in China also extends to the region. Natural hybridization between *Capsicum annum* Chinese Group and *C. annum* Bird Pepper Group = *C. frutescens*, followed by natural or farmer's selection in chilis probably evolved local landraces such as *Bhut jolokia* (Borgohain *et al.*, 2008) with high capsaicin contents. In the case of spices such as ginger and turmeric, many local cultivars with desirable features are known (Ravindran *et al.*, 2005). Among fruits, the region is known for variability in jackfruit (*Artocarpus heterophyllus*) (Karihaloo *et al.*, 2005), and in *Citrus* for the mandarin, *C. reticulata*.

A survey conducted to determine the plant-based folk medicines used by the Sonowal Kacharis tribe of the Brahmaputra Valley recorded that for the treatment of 19 locally prevalent diseases (asthma, ascariasis, diabetes, diarrhea, diuretic, dyspepsia, dysentery, dysmenorrhea, glossitis, mumps, edema in pregnancy, oliguria, paralysis, paronychia, piles, pinworm infection, scabies, scanty lactation, and tonsillitis), some of the medicinal plants used by the Sonowal Kacharis tribe include *Allium sativum*,

Oryza sativa, *Senna sophera* = *Cassia sophera*, *Ricinus communis*, and *Ananas comosus*. First-hand information on the uses of 16 wild and 11 cultivated plant species have been reported for further research and revalidation of the traditional uses of these plants (Kalita and Deb, 2006).

Future perspectives

Flooding and waterlogging is very common in the region. This has been causing excessive leaching of nutrients, making the soils poor, particularly in the upper reaches of the Brahmaputra Valley. Therefore, attention to flood control is very important and should be given foremost priority to save the crops in the region. Additionally, the acidity of the soil is also causing nutrient imbalances. These issues require appropriate research focus with the integration of modern approaches. Shifting cultivation has also been contributing to the loss of forest land and erosion of soil and soil nutrients, along with the erosion of microbial biodiversity. Therefore, *jhuming* in the hill areas needs to be minimized through stringent regulation.

The introduction of high-yielding hybrid cultivars in crops such as rice has caused a severe loss of genetic diversity of the low-yielding but nutritionally rich and disease-resistant varieties. As per one estimate, 5,000 traditional landraces cultivated and collected from the Brahmaputra Valley before the Green Revolution have been predominantly lost (Jackson, 1994). It is high time that participatory in-situ on-farm conservation is initiated with an integrated genetic enhancement program, involving the

local farmers and traditional farming communities, with incentives for cultivation, conservation, and continued evolution of the unique genetic diversity of local landraces with the help of desirable exotic germplasm. This would enable the enrichment of the genetic diversity within the changing environment so as to facilitate desirable constellations of genes in crop improvement to overcome the challenges of climatic changes.

The floodplains cover a 2.6 million ha area that is traditionally rice growing. The ecosystem in the rice-growing areas has undergone major changes as a result of various developmental activities and adoption of modern farming technology. Rice fields that were once the major source of fish for the rural farmers are now recording a sharp decline in fish population, leading to a chronic shortage of fish in the state and a deterioration of the rice ecosystem. Attention and action are urgently needed to restrict these trends.

The agroclimatic conditions of the region favor the growth of a variety of fruits, vegetables, and spices that include orange, banana, pineapple, areca-nut, coconut, guava, mango, jackfruit, citrus fruits, ginger, turmeric, chili, potato, etc., offering tremendous opportunities for horticulture-based production systems and industry. Until recently, horticulture was practiced largely as a non-commercial activity. However, with better-quality planting material, sufficient research support, and better know-how, the region could easily be poised for a major boom in the fruit-growing and food-processing industry. This

would be the first step towards exploiting the untapped potential for commercialization of agriculture in Assam. Vegetables, fruits, and spices are high-value crops with enormous scope for commercialization. In cash crops such as banana, coconut, and ginger, the productivity can be increased manifold with the use of technologies such as replacement of traditional varieties with improved ones; use of quality seed (rhizomes) and planting material (use of virus-free in-vitro propagated plants); use of pseudo-stem waste for vermicomposting; integrated nutrient management for zinc, boron, manganese, etc.; coconut-based farming system with Assam Green Tall and hybrid (WCT × MYD); high-density multispecies cropping system with coconut, pepper, ginger, Assam lemon, and banana; planting on raised beds with appropriate spacing; seed treatment to protect against the rhizome rot disease; and adoption of grading, curing, and storage techniques.

Lastly, as suggested by Singh *et al.* (2007), the authorities concerned may initiate registration of *Camellia assamica* (indigenous tea species) and *Antheraea assama* (indigenous Muga silkworm) under the 'Geographical Indications of Goods (Registration and Protection) Act, 1999' of India, which is necessary to ensure protection for the innovation and trading rights of the local communities residing under such Agricultural Biodiversity Heritage Sites. There is a need to build proper strategy and infrastructure to claim protection for as many biodiversity-derived products as possible, before they become 'generic names'.

The introduction of high-yielding hybrid cultivars in crops such as rice has caused a severe loss of genetic diversity of the low-yielding but nutritionally rich and disease-resistant varieties. As per one estimate, 5,000 traditional landraces cultivated and collected from the Brahmaputra Valley before the Green Revolution have been predominantly lost.

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