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Probable Agricultural Biodiversity Heritage Sites in India: XIII. Lower Gangetic Plain or Delta Region

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Abstract

The Lower Gangetic Plains, situated to the southeast of the Middle Gangetic Plains, is the delta region resulting from the confluence of the rivers Ganga and Brahmaputra, before they meet the Bay of Bengal. The Lower Gangetic Plains region is more humid, with large parts of the land inundated for the major part of the year. The continued deposition of silt producing fertile alluvial soil has made this region one of the most fertile and thickly populated regions in the world. Most inhabitants (up to 94 per cent in the Sundarbans) depend on agriculture. The region is rich in biodiversity, particularly in the aquatic biodiversity and mangroves found in the swampy forests of the Sundarbans, and is declared a World Heritage Site by UNESCO. The region's agriculture is very old, initiated in the Paleolithic period by non-Aryan Austric-speaking peoples, but later influenced by several cultures both from neighboring Mongolians and Aryan, and far west Minoan civilization of Crete as reflected by archaeological evidences. The region can be credited for the development of wetland agriculture involving water-loving crop species, such as rice and jute, for the cultivation of a large number of varieties of long-stemmed rice in the swamps and deep morasses, for postharvest storage technologies, and for boat manufacturing and shipping skills and maritime trade. In Greek and Latin literature, this region was referred to as Gangaridai, *a maritime country where trading ships came from various parts of the world. The region was known for the finest of silk and muslin cloth. Culturally, with the extension of Aryan culture, it came under the influence of Aryans and interacted with local Austric and Dravidian tribes from the south, producing a unique synthesis of Aryan-Dravidian culture. Cultures from other parts of the world also had an influence. For these reasons, the present article proposes the region to be another National Agricultural Biodiversity Heritage Site with appropriate analyses and justification based on facts.*

The Lower Gangetic Plains (LGP) of the Indo-Gangetic Plains is the extension of the Middle Gangetic Plains (MGP) to the southeast, and is particularly characterized by its greater humidity. The rainfall in the region is around 1,700 mm or more. The soil is rich *bhangar*, suitable for rice cultivation. Part of the plains has a coastal climate with unique vegetation. The fertile alluvial plains, which earlier had rich vegetation of moist deciduous broad-leaved forest, has been

cleared and is being intensely cultivated from centuries like the other parts of the Indo-Gangetic Plains. Consequently, the majority of the people of the region are involved in agricultural activities with the densest human populations on the earth. However, the human interactions with the unique landscape [created as a result of the confluence of the two large rivers Ganga (Ganges) and Brahmaputra before they go down into the Bay of Bengal], have been distinct and unique, harmonizing the biodiversity with ecological conditions and transforming the region into an area of specialized, distinct and specific agriculture, predominantly based on water-loving crop species and cultures. This is reflected in the products and technology discovered in the archaeological remains. The region can be credited for evolving the triple-cropping system due to the prolonged availability of moisture, for the domestication of jute, and for generating unique and specific diversity suited to unique ecologies of the region and consumer demands, including staple food crops such as rice, and for postharvest grain storage. Like the two other regions of the Indo-Gangetic Plains, the LGP has a large number of sites with Neolithic characteristics indicating the practice of agriculture from the early time of human settlement. With the introduction of copper, a new era of Chalcolithism evolved in the region resulting in certain innovations, discovered at sites such as Pandu Rajar Dhibi, Mangalkot (District Burdwan), Hathikhera, Mahishdal (District Bankura), etc. During subsequent evolution, iron was introduced in the region, as it appeared, as Black and Red ware in the Pre-Northern Black Polished Ware levels, in sites such as Pandu Rajar Dhibi. Iron technology enabled the early farmers to clear the dense and tangled forests for cultivation. Thus, the summary of archaeological and literary evidence indicates that in addition to the other progress and development common with the other two regions of the Indo-Gangetic Plains (such as MGP), rice was the main crop of the Chalcolithic period, with Mangalkot yielding rice from a hearth (Ray, 1987). The discovery of silos having a capacity of about 9 quintals for the storage of paddy at Mahishdal, reveal the progress made in postharvest and storage technologies, probably needed because of the prevalence of the extremely humid climate conditions, and to provide continued support to the livelihood and food security of the growing population (Ghosh, 1984). The archaeological sites also reflected establishment of prosperous agricultural communities in the region, living in small- to medium-sized villages (Singh, 1990). Further, interacting with the coastal landscape, the people of the region developed boat manufacturing, fishing, and shipping skills, evolving maritime trade and commerce, as the alternative profession. For maritime trade and commerce, the

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region was known throughout the world as a maritime country, called *Gangaridai*. For these reasons, the region is being proposed as another National Agricultural Biodiversity Heritage Site, based on the indices established by Singh and Varaprasad (2008).

Location and extent

The LGP has the shape of a triangle, and is considered to be an "arcuate" delta (arc-shaped). It is a *Riverine Delta* situated just above the Bay of Bengal, with a major portion falling into Bangladesh (Fig. 1). The delta is over 350 km wide along the Bay of

Figure 1. Extent and limits of the Lower Gangetic Plains (dotted line).

Bengal. As the silts are brought in by the rivers annually by the normal flow and flood, it is a growing delta, the largest in the world, with extremely fertile and vegetated alluvial land. It is also called *The Green Delta* or the *Ganges–Brahmaputra River Delta*.

The LGP arises from the confluence of the following major rivers: the Ganges running horizontally from the west and then running down to meet the ocean, the Brahmaputra, stretching from the northeast of India to the south and ending in the sacred Ganges, and the Meghna, the wide river then flowing further south in the confluence of River Padma and ending in the Bay of Bengal with new alluvial land (*chars*) each year (Fig. 1). Administratively, in the north it is bounded by the parts of undivided Bengal, in the west by Jharkhand and Orissa, and in the east by the northeastern hill states of India, while in the south it runs into the Bay of Bengal (Fig. 1).

At the physical level, the LGP (Ganges Delta) of undivided India is made up of three major regions: (i) *Brahmaputra Alluvium*, comprising part of the districts of Dhaka, Mymensingh, Tangail, and Comilla of Bangladesh, (ii) *Ganges Alluvium*, comprising part of the districts of Kushtia, Jessore, Khulna, Rajshahi, Pabna, and Dhaka of Bangladesh and a major portion of West Bengal (India), and (iii) *Tessta Silt*, comprising part of Dinajpur, Rangpur districts, East Bogra, and Sirajganj of Bangladesh and parts of West Bengal (India) (Fig. 1).

The LGP falling in India consists of four plains: (a) *Barind Plains West Bengal*: West Dinajpur, Maldah; (b) *Central Alluvial Plains*: Murshidabad, Nadia, Bardhaman, Hoogly, Howrah, and Medinipur; (c) *Alluvial Coastal Saline Plains*: North and South 24 Parganas; and (d) *Rorh Plains*: Birbhum and Bankura. Administratively, it includes the districts of North 24 Parganas, South 24 Parganas, Howrah, Hoogly, Nadia, Bardhaman, Birbhum, and Murshidabad.

Landscape

The landscape of the region is the vast river system with three major landforms: the Uplands, Old Fluvial/Deltaic Plains, and Young Fluvial Plains (Singh *et al.,* 1998). The upper reaches of the LGP consist of moist deciduous forests that extend across the alluvial plain of the lower Ganges and Brahmaputra rivers, which run the length of the Himalayan foothills and drain its breadth, to form the world's largest river delta. Only about three per cent of the ecoregion is now under natural forest, with only one large block of intact habitat remaining. The middle ecoregion consists of the fertile old alluvial plains, where the forests have largely been replaced with intensive agriculture, which supports one of the densest human populations on earth. The alluvial substrate deposited by the rivers in this region is clayey and drains poorly, but on the more stable but flood-prone riverine flats, the soil tends to be sandier with only local clay patches. The lower deltaic region is composed of a labyrinth of channels, swamps, lakes, and floodplain sediments (*chars*). Thick stands of tall grass, known as canebrakes, grow in these areas. Where the delta meets the Bay of Bengal, the Sundarbans mangroves form the world's

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largest mangrove ecoregion, covering an area of 20,400 km^2 in a chain of 54 islands (Fig. 2). The Sundarbans freshwater swamp forests ecoregion, lies closer to the Bay of Bengal, and is flooded with slightly brackish water during the dry season and fresh-water during the monsoon season. These forests too, have almost been completely converted to intensive agriculture (Fig. 3). The Sundarbans derive their name from the predominant mangrove species, *Heritiera fomes* Wall., which is locally called *sundri* or *sundari*. Thus, the Sundarbans are a part of the world's largest delta covered by mangrove forest and vast saline mud flats. The whole tract reaches inland for

Figure 2. The Sundarbans, with unique and rich mangrove diversity (Source: www.kolkatabirds.com).

Figure 3. Diverse agriculture with rich crop diversity dominated by rice (Source: www.wikipedia.org).

100–130 km, with a network of estuaries, tidal rivers, and creeks intersected by numerous channels, enclosed flats, marshy islands covered with dense forests. In 1997, the Sundarbans were awarded the status of World Heritage Site by the UNESCO.

The common soil-scape of the region is represented by level to very gently sloping Haplustalfs/Sapludalfs (Sehgal *et al.,* 1992). Agriculturally, the delta can be separated into two parts: the eastern (active), and the western (less active) areas. Most of the delta is composed of alluvial soils, with red and red-yellow laterite soils found farther to the east. The soil has large amounts of minerals and nutrients, which are good for agriculture.

Agroclimate

Climatologically, the region can be classified into: Tropical humid, Tropical moist humid, and Tropical subhumid. The overall climate of the region is characterized by hot summers and mild winters. The region receives high rainfall both during summer and winter,

ranging from 1,400 to 2,000 mm or even more. The potential evapotranspiration (PET) ranges from 1,000 to 1,400 mm, reflecting that precipitation exceeds PET for the major part of the year, and that the precipitation satisfies 80 per cent of the water requirement. The dry period is only for a month or so with a water deficit of around 400 mm. The region experiences water stress from March to May. Therefore, the growing season in the region ranges from 150 to 270 days. The soil moisture regime is ustic (Sehgal *et al.,* 1992).

The LGP is the eastern part of the Indo-Gangetic Plain and one of the most important agricultural ecoregions in the world (Timsina and Connor, 2001). Most of the LGP is now part of Bangladesh (i.e., of the erstwhile undivided Bengal). In present-day India, most of the region lies in the state of West Bengal, which is further divided into six agroclimatic subregions: (i) the northern hilly zone, (ii) the Tarai-Teesta floodplain, (iii) the Gangetic floodplain, (iv) the coastal floodplain, (v) the Vindhya old floodplain, and (vi) the undulating lateritic subregion of the Eastern Plateau Region (Sen Gupta, 2001). The Gangetic delta has fertile alluvial plains with soil mostly clayey in texture.

Floristic diversity

The tropical moist deciduous forests found in the lower reaches of the Ganges and Brahmaputra rivers once stretched along the plains across the Indian states of Uttar Pradesh, Bihar, West Bengal, Assam, and Orissa, and most of Bangladesh. The vegetation is semi-deciduous, with the upper canopy containing the deciduous species, while the second story is dominated by evergreen species. Open forests are dominated by *semal* (*Bombax ceiba* L.) in association with *Albizia procera* Benth., *Duabanga sonneratioides* Buch.-Ham., and *Sterculia villosa* Roxb. These are early seral communities that will eventually become *sal* (*Shorea robusta* C.F.Gaertn.) forests, if succession is allowed to proceed. But in most places the forests fail to reach a climax for various reasons (mostly human-caused) perpetuating the sub-climax community.

The riparian forests of the region are characterized by an *Acacia–Dalbergia* association that includes *Acacia catechu* Brandis, *Albizia procera*, *Bombax ceiba*, *Sterculia villosa*, and *Dalbergia sissoo* Roxb. In the upper region, the forests are made up of *Duabanga–Pterospermum–Terminalia* in association with *Bombax ceiba*, *Pterospermum acerifolium* Benth., *Laportea crenulata* Wight, *Duabanga sonneratioides* Buch.-Ham., *Terminalia myriocarpa* Van Heurck & Müll.Arg., and *Calamus tenuis* Roxb.

In permanently wet or moist areas with fine clayey soils and a rich humus layer, impenetrable canebrakes grow profusely in the understory. Annual fires are common, so fire-hardy species, such as *Ziziphus*

Where the delta meets the Bay of Bengal, the Sundarbans mangroves form the world's largest mangrove ecoregion, covering an area of 20,400 km² in a chain of 54 islands.

mauritiana Lam. (syn. *Z. jujuba* Mill.), *Z. vulgaris* Lam., *Madhuca indica* J.F. Gmel. (syn. *M. longifolia* Macbride), *Aegle marmelos* (L.) Correa ex Roxb., *Butea monosperma* (Lam.) Taub., *Terminalia tomentosa* Wight & Arn., *Ochna pumila* Buch.-Ham. ex D.Don, and several others also occur in these fire-prone areas. The other associated trees are *Ceriops decandra* (Griff.) Ding Hou, *Excoecaria agallocha* L., *Heritiera fomes,* and *Phoenix paludosa* Roxb. Some of the common trees occurring in the plains are *Butea monosperma, Haldina cordifolia* (Roxb.) Ridsdale [syn. *Adina cordifolia* (Roxb.) Bra], *Mangifera indica* L., *Madhuca indica, Shorea robusta, Terminalia arjuna* (Roxb. ex DC.) Wight & Arn., and *Terminalia chebula* Willd. ex Flem.

The area is very rich in floristic diversity in the swampy mangrove forests (Fig. 2). This natural vegetation of littoral swamp forests is called Sundarbans, because of the dominant mangrove species *Heritiera fomes*, called the *Sundari*. The mangrove vegetation is dominated by *Rhizophora mucronata* Lamk., *R. apiculata* Blume, *Kandelia candel* Druce, *Aegiceras corniculatum* (L.) Blanco, *Bruguiera gymnorrhiza* (L.) Lamk., *Xylocarpus granatum* Koen., and *Avicennia officinalis* L.

The mammal fauna consists of 126 known species, including one near-endemic species of bat, *Tadarida teniotis* Rafinesque. There are more than 380 known bird species, although none are endemic. The rich aquatic fauna is represented by approximately 300 species of fish.

Agriculture and agrobiodiversity

The LGP is the largest floodplain (19,389 km^2) of the Gangetic Plains, and the most fertile subregion. Predominantly, these are man-made fertile alluvial plains cleared of forests and presently intensely cultivated. The human activities in the region date back to thousands of years. Approximately two-thirds of the people work in agriculture, and grow various crops on the fertile floodplains of the delta. The major crops are rice, jute, and horticultural crops. Fishing is also an important activity in the delta region, with fish being a major source of food for most people in the area.

The availability of moisture for the most part of the year has permitted the evolution of a triple-cropping system. The three cropping seasons include a rainy or *kharif* season from June to October; a winter or *rabi* season from November to February; and a summer or *dry* season from March to May. Traditionally, the region is primarily a rice-growing area. On medium lands, after the harvest of the long-duration, photosensitive local rice grown during the rainy season, farmers traditionally grow pulses such as grass pea, lentil, or chickpea (Bengal gram) in winter, on residual moisture. However, the productivity and return on these crops are low. Though rainfed agriculture is the traditional farming system of the region, in some pockets irrigated farming has also evolved. But the main crop cultivated both in *kharif* and *rabi* seasons has remained rice only.

Jute is the other major crop of the region, cultivated as an additional/alternate crop, particularly in the areas prone to flooding

(Fig. 4). More than 85% of the world production of jute comes from the Gangetic delta region. The soil of the Ganges delta creates a great platform for growing jute and other allied fiber crops, such as sunn hemp. Rich loam and riverine silts make the best composition of soil and mineral structure for growing jute. Each year, additional silts are brought in by the flood, a devastating phenomenon that is highly favorable for the production of jute and other fiber crops. Therefore, the century-old experienced jute farmers in this region go through much misery to produce quality jute.

Jute cultivation in the region can be classified into three areas: (i) *Brahmaputra Alluvium*, also called the *Jat* Area, which is inundated and replenished every year by fresh alluvial deposit, having soils acidic in nature, but produces the best quality jute (mostly Bangladesh) of the region; (ii) *Ganges Alluvium*, also called the *District* Area, has alkaline side of neutrality soils, and produces next to *Jat* jute in order of quality; and (iii) *Teesta Silt*, also called the *Northern* Area, which has a sandy soil with lower moisture retention capacity and therefore produces an inferior quality of jute.

Figure 4. Commercial cultivation of jute (Source: www.informedfarmers.com).

The major cropping systems prevalent in the region are: rice–wheat, rice–potato, jute–wheat, jute–rice–sunflower, jute–mustard, rice–mustard, jute–rapeseed–rice, sesame–groundnut–sunflower, pulses–wheat, rice–vegetables, rice–wheat–summer rice, which have been evolved by the local farmers based on their ingenuity and life-time experiences. Biswas *et al.* (2006), while making an integrated assessment of the cropping systems in the region, concluded that compared to new triple-cropping system involving potato, traditional systems, such as jute–wheat, jute–rapeseed–rice, and rice–wheat, require fewer inputs and involve less risk, making them more suitable for resource-poor small farmers of the region. In the crop rotation, rice or wheat is taken after rice/jute.

The availability of moisture throughout the year has made horticulture, including floriculture an important component of agricultural cropping and/or production systems. Some of the horticultural and supplementary crops grown in the plains are aroids and cucurbits among vegetables, and banana, coconut, mango, papaya among fruits.

Fishing is also an important activity in the delta region, with fish being a major source of food for many of the people in the area. Fish farming, either independently or in combination with rice, is an important source of livelihood for farmers. The common species of domestic fish are *rohu*, *katla*, *bata*, etc.

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Representative crop species in various crop groups

Cereals, pseudocereals, and millets. Amaranth (*Amaranthus hypochondriacus* L.), barley (*Hordeum vulgare* L.), barnyard millet (*Echinochloa frumentacea* Link; syn. *Panicum frumentaceum* Roxb.), finger millet [*Eleusine coracana* (L.) Gaertn.], foxtail millet [*Setaria italica* (L.) Beauv.], kodo millet (*Paspalum scrobiculatum* L.), maize (*Zea mays* L.), rice (*Oryza sativa* L.), sorghum [*Sorghum bicolor* (L.) Moench], and wheat (*Triticum aestivum* L.).

Grain legumes and oilseeds. Chickpea (*Cicer arietinum* L.), common vetch (*Vicia sativa* L.), grass pea (*Lathyrus sativus* L.), green gram [*Vigna radiata* (L.) Wilczek var. *radiata*], groundnut (*Arachis hypogaea* L.), horsegram (*Dolichos biflorus* Linn.), Jerusalem artichoke (*Helianthus tuberosus* L.), lentil (*Lens culinaris* Medic), mustard (*Brassica campestris* L., *B. tournfortii* Gouan), pigeonpea [*Cajanus cajan* (L.) Millsp.], sesame (*Sesamum indicum* L.; syn. *S. orientale* L.), and sunflower (*Helianthus annuus* L.).

Fodder and fiber crops. *Bargad* (*Ficus benghalensis* L.), *bhalai* [*Imperata cylindrica* (L.) P.Beauv.], Comilla cotton (*Gossypium arboreum/herbaceum* L.), grass [*Paspalidium flavidum* (Retz.) A.Camus], *peepal* (*Ficus religiosa* L.), *tossa* jute (*Corchorus olitorius* L.), and white jute (*Corchorus capsularis* L.). The other allied fiber crops cultivated are flax (*Linum usitatissimum* L.), kenaf or mesta (*Hibiscus cannabinus* L. and *H. sabdariffa* L.), ramie [*Boehmeria nivea* (L.) Gaud.], *sisal* (*Agave sisalana* Perr.), sunn hemp (*Crotalaria juncea* L.), and tree cotton (*Gossymium arboretum* var. *conansis* L.).

Vegetables. Ash gourd [*Benincasa hispida* (Thunb.) Cogn.], *bhindi* or okra [*Abelmoschus esculentus* (L.) Moench], bitter gourd (*Momordica charantia* L.), bottle gourd [*Lagenaria siceraria* (Molina) Standley], cabbage [*Brassica oleracea* var. *capitata* (L.) DC.], cauliflower (*Brassica oleracea* var. *botrytis* L.), cucumber (*Cucumis sativus* L.), French bean (*Phaseolus vulgaris* L.), *kundri* (*Coccinia indica* Wight & Arn.; syn. *C. grandis* Voigt), lablab bean [*Lablab purpureus* (L.) Sweet], musk melon (*Cucumis melo* L.), pea (*Pisum sativum* L.), brinjal (*Solanum melongena* L.), pointed gourd (*Trichosanthes dioica* Roxb.), ridged gourd [*Luffa acutangula* (L.) Roxb.], small bittergourd (*Momordica dioica* Roxb. ex Willd.), *sobhanjana* (*Moringa pterygosperma* Gaertn.), sponge gourd (*Luffa cylindrica* Roxb.; syn. *L. aegyptiaca* Mill.), summer squash (*Cucurbita pepo* L.), sweet gourd [*Momordica cochinchinensis* (Lour.) Spreng], tomato (*Lycopersicon esculentum* Mill.), and winged bean [*Psophocarpus tetragonolobus* (L.) DC.].

Leafy vegetables. *Bathua* (*Chenopodium album* L.), green amaranth (*Amaranthus*

caudatus L., *A. gangeticus* L., *A. paniculatus* L.), Indian spinach (*Basella alba* L., *B. rubra* L.), purple amaranth (*Amaranthus atropurpureus* Roxb.), spinach (*Spinacia oleracea* L.), and water spinach (*Ipomoea aquatica* Forsk.).

Bulb and tubers. *Arvi* or taro [*Colocasia fallax* Schott, *C. esculenta* (L.) Schott], carrot (*Daucus carota* L.), elephant yam [*Amorphophallus campanulatus* (Roxb.) Bl.], *kukur alu* (*Dioscorea puber* Blume; syn. *D. anguina* Roxb.), potato (*Solanum tuberosum* L.), radish (*Raphanus sativus* L.), sugar beet (*Beta vulgaris* L.), taro (*Alocasia indica* Schott), turnip (*Brassica rapa* L. var. *rapa*), voodoo lily (*Amorphophallus bulbifer* Blume), yam [*Amorphophallus sylvaticus* (Roxb.) Kunth., *Dioscorea esculenta* (Lour.) Burk., *D. kalkapershadii* Prain & Burkill., *D. pentaphylla* L. (syn. *D. jacquemontii*)], and yam bean [*Pachyrrhizus tuberosus* (Lam.) Spreng., *P. erosus* (L.) Urban], introduced.

Fruits. *Aonla* or Indian gooseberry (*Emblica officinalis* Gaertn.), avocado (*Persea americana* Mill.; recent introduction), *bael* (*Aegle marmelos*), banana (*Musa paradisiaca* L.; *M. superba* Roxb.), *ber* (*Ziziphus rugosa* Lam.; syn. *Z. glabra* Roxb.), *chakotra* or pomelo [*Citrus maxima* (Burm.) Merr. or *C. grandis* Osbeck], date palm [*Phoenix robusta* (Becc.) Hook. f., *P. sylvestris* (L.) Roxb.], guava (*Psidium guajava* L.), jackfruit (*Artocarpus heterophyllus* Lam.), *jamun* [*Syzygium cuminii* (L.) Skeels], *karonda* (*Carissa carandas* Lour.), *kaith bel* [*Limonia acidissima* L.; syn. *Feronia elephantum* Correa, *F. limonia* Swingle], *Hesperethusa crenulata* (Roxb.) M.Roem., *Schinus limonia* L.], *lasora* (*Cordia myxa* Roxb.; syn. *C. dichotoma* Forst.), mango (*Mangifera indica*), papaya (*Carica papaya* L.), *phalsa* (*Grewia asiatica* L.), *sapota* [*Manilkara zapota* (L.) P.Royen], toddy palm (*Borassus flabellifer* L.), and watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai].

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Spices. Black pepper [*Piper nigrum* L. (Lam. ex Link)], chili (red and green) (*Capsicum annuum* L.), coriander (*Coriandrum sativum* L.), garlic (*Allium sativum* L.), ginger (*Zingiber officinale* Rosc.), *haldi* or turmeric (*Curcuma domestica* Valet.; syn. *C. longa* L.), *kali haldi* (*Curcuma caesia* Roxb.), Mexican coriander (*Eryngium foetidum* L.), and onion (*Allium cepa* L.).

Other crops. Coconut (*Cocos nucifera* L.), *pan* or betel leaf (*Piper betel* L.), sugarcane (*Saccharum officinarum* and *S. barberi* Jeswiet; syn. *S. sinense* Roxb.), tobacco (*Nicotiana tabacum* L.), etc.

Ornamentals. The availability of moisture throughout the year has supported the cultivation of ornamental plant species from

ancient times, as described in the *Ramacharita*. Even today, they are propagated and raised in nurseries and supplied to the rest of the country. Some of the commonly cultivated/ propagated flowering plants in this region are: Anthurium (*Anthurium* Schott spp., introduction), begonia (*Begonia* L. spp.), *bel mallika* or Arabian jasmine (*Jasminum sambac* Soland.), caladium (*Caladium* Vent., introduction) camellia (*Camellia* L. spp.), Cape jasmine (gardenia) (*Gardenia jasminoides* Retz.), *chameli* or Italian or Royal jasmine (*Jasminum humile* L.), Chinese rose (*Hibiscus rosa-sinensis* L.), chrysanthemum (*Chrysanthemum indicum* L.), eucharis (*Eucharis* Planch & Lind., recent introduction), freesia (*Freesia* Klatt. spp., recent introductions), gerbera (*Gerbera* L. spp.), gladiolus (*Gladiolus communis* L.), gloriosa (*Gloriosa superba* L.), haemanthus (*Haemanthus* L. spp., recent introduction), hollyhock (*Alcea rosea* L.; syn. *Althaea chinensis* Wall., *A. ficifolia* Cav., *A. rosea* Cav.), jasmine (*Jasminum fructicans* L.), lilies or zephyranthes (*Zephyranthes* Herb. spp.), lotus (*Nelumbo nucifera* Gaertn.), rose (*Rosa* L. spp.; *R. chinensis* Jacq.), tuberose (*Polianthes tuberosa* L.), and different types of orchids.

Medicinal and aromatic plants. Some of the common medicinal plants available wild in the region are: *aamra haridra* (*Curcuma amada* Roxb.), *Acanthus ilicifolius* L. (Sundarbans), *helencha* (*Enhydra fluctuans* Lour.), *jatamansi* or muskroot (*Nardostachys grandiflora* DC), *kali haldi* (*Curcuma caesia* Roxb.), *karchuura* (*Curcuma zedoaria* Rosc.), nux-vomica (*Strychnos potatorum* L.; syn. *S. nux-vomica* L.), *piasal* or Indian kino (*Pterocarpus marsupium* Roxb.), *Trigonella corniculata* (L.), *tvakshira* (*Curcuma angustifolia* Roxb.), and *van haridra* (*Curcuma aromatica* Salisb.). Recently, cultivation has been taken up of *anantamul* or *kapuri* [*Hemidesmus indicus* (L.) R.Br. ex Schult.], *antamul* (*Tylophora indica* Merr.), *ashwagandha* [*Withania somnifera* (L.) Dunal.], *ayapana* (*Eupatorium ayapana* Vent.), *chirata* (*Swertia chirata* C.B.Clarke), *ghritakumari* [*Aloe vera* (L.) Burm.f.], *sarpagandha* (*Rauvolfia serpentina* Benth. ex Kurz.), and aromatic plant – lemon grass [*Cymbopogon flexuosus* (Steud.) Wats.], and citronella (*Cymbopogon* Spreng. spp.).

Timber. Sal (*Shorea robusta*), *semal* (*Bombax ceiba*), *sheesham* (*Dalbergia sissoo*), teak (*Tectona grandis* L.), etc.

Multipurpose species. *Arjun* (*Terminalia arjuna*), *Polyalthia suberosa* (Roxb.) Thrwaites, bamboo (*Bambusa balcooa* Roxb.), *gol pata* (*Nypa fruticans* Wrumb.), *harda* (*Terminalia chebula*), iron bamboo (*Dendrocalamus strictus* Nees.), *kachnar* (*Bauhinia vahlii* Wight & Arn.), *mahua* (*Madhuca indica* J.F. Gmel.; syn. *M. longifolia* Macbride), mangrove date palm (*Phoenix paludosa* Roxb., *P. sylvestris*), monkey jack (*Artocarpus lakoocha* Roxb.), sesban (*Sesbania aegyptiaca* Pers.), tamarind (*Tamarindus indica* L.), and tiger grass [*Thysanolaena maxima* (Roxb.) Kuntze].

Gum- and resin-yielding plants and forest products. The farmers from tribal areas collect 'butea *gum*' or '*Bengal* kino' (*Butea monosperma*), *hing* (*Ferula foetida* St.-Lag.), sal leaves and seeds; *kandu* leaves for making local *bidi*, mahua flowers, mushrooms and tubers and leafy vegetables

such as *kural*, *ban puri*, *bhaker* root, *chuths* for food and *pyan lata*, *alok lata* (*Cuscuta* L. spp.), citronella (*Cymbopogon* spp.), turmeric, and other medicinal herbs.

Wild relatives. Arora and Nayar (1984) recorded wild relatives of crop species, such as, *Amorphophallus bulbifer* Blume, *Cajanus volubilis* Blanco (syn. *C. crassa* Prain.), *Cucumis setosus* Cogn., *Curcuma amada* Roxb., *Echinochloa crus-galli* (L.) P. Beauv., *Oryza coarctata* Roxb. [syn. *Sclerophyllum coarctatum* (Roxb.) Griff.], *O. rufipogon* Griff., and *Trichosanthes cucumerina* Linn. However, some more species are found to occur in the region, such as *Abelmoschus manihot* (L.) Medik., *Carthamus oxycantha* Bieb., *Chenopodium album* L., *Coix agrestis* Lour., *Coix aquatica* Roxb., *Corchorus trilocularis* L., *Echinochloa colonum* L., *Lactuca remotiflora* DC., *Momordica subangulata* var. *renigera* (Wall. ex G.Don) W.J.de Wilde., *Oryza coarctata* [*Porterasia coarctata* (Roxb.) Tateoka] – tetraploid, *Phoenix paludosa* Roxb., *Piper sylvaticum* Roxb., *Prunus rufa* Hook. f., *Saccharum spontaneum* L., *Solanum incanum* Ruiz & Pav., *Solanum indicum* L., *Syzygium heyneanum* Wall., *Taxus wallichiana* Zucc. var. *chinensis* (Pilg.) Florin, *Trigonella occulta* Delile, and *T. polycerata* L.

Endemic species. Like the other Indo-Gangetic plains, endemic plant species are very few, as most species found extend over to the peninsular region of the country. However, ecotypes and species, such as *Leucas helectrifolia, Phoenix paludosa, Dimeria ornithopoda* Trin. var. *gracillima* Bor. may be considered endemic. *Cardenthera uliginosa* Buch.-Ham. var. *birbhumensis* (Birbhum), *Cuscuta sharmanum* Mukerjee & J.K.Bhattacharyya (Midnapur) are some other species reported endemic.

Theatened species. *Oryza officinalis, Nypa fruiticans, sundari (Heritiera fomes*) from India, and many more, including *Adina cordifolia, Tamarindus indica, Diospyros cordifolia* Roxb., *Sterculia foetida* L., *Mesua ferrea* L., *Bauhinia malabarica* Roxb., *Aquilaria agallocha* Roxb. from Bangladesh (Huq and Banik, 1992; Chowdhury, 1996) have been reported endangered. Similarly, 56 species of freshwater fish including 11 cyprinids are endangered or near extinction from the Bangladesh region (IUCN, 1998). Under the project funded by UNDP through the Ministry of Environment and Forest in West Bengal, 46 medicinal plant species were identified endangered (Source: westbengalforest.gov.in/update_26-3-2010/frlht_status_report.pdf, 2008). Representative plant species under threat are listed in Table 1.

Associated culture and tribes

It is now generally agreed that the foundations of the agriculture-based village life, which is believed to be one of the foundations of Indian civilization, were laid by the Austric-speaking peoples or Nishadas in the LGP region much before the arrival of the Aryans. They were succeeded by the Alpine race. The excavations at Pandu Rajar Dhibi (West Bengal) prove that at least 2,000 years before the beginning of the Gregorian (Western) calendar, Bengal possessed a

Table 1. Representative plant species under threat in the Lower Gangetic Plain or Delta region.

Species	Family	Habit	Threat level[1]	Remark
Adina cordifolia[2]	Rubiaceae	Tree	EN	Medicinal
Aquilaria agallocha (syn. *A. malaccensis* Lamk.)[2]	Thymelaeaceae	Tree	EN	Fragrant agarwood used for incense, traditional medicine
Bauhinia malabarica[2]	Caesalpiniaceae	Tree	EN	Medicinal, ornamental
Diospyros cordifolia[2]	Ebenaceae	Tree	EN	Medicinal, wood
Heritiera fomes	Malvaceae	Tree	EN	Dominant mangrove tree
Mesua ferrea[2]	Clusiaceae	Tree	EN	Ornamental
Nypa fruiticans	Arecaceae	Tree	EN	*Gola pata*, mangrove palm
Oryza officinalis	Poaceae	Tall herb	I	Rice genetic resource
Sterculia foetida[2]	Sterculiaceae	Tree	EN	Oil-rich seeds
Tamarindus indica[2]	Fabaceae	Tree	EN	Spice, avenue/ornamental tree

1. EN = Endangered; I = Indeterminate.
2. Source: Bangladesh: Country report to the FAO international technical conference on plant genetic resources at Leipzig, Germany.

non-Aryan culture, based on the use of iron implements, specific black and red ware and some wet rice cultivation, and also that the region had contacts with overseas cultures. This is corroborated by the literary evidences on: (i) the movement of the Palaeolithic people (nomadic) from northern India toward the east over the Bengal delta; (ii) the similarity of archaeological findings from the upper Palaeolithic culture of Kalimpong with those of China and Southeast Asia, suggesting that some people moved into this region from Tibet and the adjoining areas of China; and (iii) the find of a seal at Pandu Rajar Dhibi, similar to the Minoan seals of Knossos, which led many to speculate that the coastal regions of eastern India may have established contacts with the Minoan civilization of Crete (Mukherjee, 2004).

As per most ancient writings, Aryanization extended to LGP from about the second millennium BCE. Gradually, the indigenous tribes of the region, such as the *Vangas*, *Sumahs*, *Sabaers*, *Pulindas*, *Kiratas*, and *Pundras*, were brought into the framework of Aryan society by classifying them as Kshatriyas. The first clear references to the *Vangas* occur in some ancient epics and the *Dharmasutras*. In the great epic Mahabharata, the *Vangas* and the *Pundras* are referred to as well-bred Kshatriyas. When the Chinese traveler Fa Hien came to Bengal in the 5th century, he saw the region flourishing with Aryan learning and culture. The earliest Buddhist literary reference to *Vanga* is contained in the *Milinda-panho*. It mentions *Vanga* as a maritime country where trading ships came from various parts of the world. Greek and Latin writers referred to the region as

Gangaridai (*Ganga Rashtra* in Sanskrit, meaning *Nation on the River Ganges*), the present-day Bengal, existing around 300 BCE [Ptolemy: Describing Ancient India (John W McCrindle, p. 172); Periplus: the Erythraean Sea (Wilfred H Schoff, pp. 47–48)]. Historians from Alexander's period refer to the *Gangaridai* as a nation possessing the greatest number and the largest elephants (Majumdar, 1960). The Pala kings ruled the region between the 8th and 12th centuries; they first ruled over Varendra and then gradually brought *Vanga* and Magadh under their rule. The Palas were Buddhists, and Buddhism continued in the region up to the end of the Pala period. The Sena rulers, who originally came from Karnataka, succeeded the Palas and introduced the caste system of 'Aryandom' (Majumdar, 1971) and revived Hinduism. This reflects an indigenous and ancient natural dispersal of Aryan philosophy across the Indian subcontinent from north to south and vice-versa, negating the belief of Aryan and Dravidian divides (Sengupta, 2008). Later, the Muslims succeeded the Senas and spread Islam. These interactions with races from other parts of India and overseas cultures resulted in the development of a composite culture in the region, reflecting a synthesis of Dravidian and Aryan cultures. By the end of the 15th century, Vaishnavism grew under Shri Chaitanya, and later under Bhaktivedanta Swami Prabhupada.

Among the population groups who lived in ancient times, the most notable were the *Pundra*, the *Vanga*, and the *Sumba*. The *Pundra* and the *Vanga* were the earliest ancestors of the people settled in the region. Their reference in post-Rigvedic literature clearly indicated their population-settlement, and that the region draws its name Bengal, from the tribe *Vanga* or *Banga*. These aboriginal populations were primarily different Dravidian tribes. Later, they evolved with the composition of diverse racial elements: Northern Indian Aryan longheads, Alpine shortheads, Dravido-Munda longheads, and Mongolian shortheads.

The tribes living in the region can be classified into: (1) Aboriginal tribes: represented by *Bumij*, *Chakma*, *Dhomal*, *Garo*, *Hajong*, *Kharria*, *Kharwar*, *Khasiya*, *Kol*, *Kuki*, *Lushai*, *Lepcha*, *Mech*, *Murmi*, *Nat*, *Santhal*, *Tipperah* or *Mroong*, *Uraon*, *Dhangar*, etc.; (2) Semi-Hinduised aboriginals: represented by *Bagdi*, *Bahelia*, *Bauri*, *Bediya*, *Bhuiya*, *Bind*, *Buna*, *Chain*, *Chamar* or *Muchi* – [a] *Kural* or *Kuril*; '*Chandal*' – [a] *Abashan, Dom* – [a] *Turi*, *Doshad*, *Hadi Hatri*, *Hari*, *Kaora*, *Karanga*, *Khaira*, *Khyen*; *Koch* – [a] *Pali* or *Paliya*, [b] *Rajbansi*, *Kodmal*, *Mahili*, *Mal*, *Malo*, *Mandai*; *Mihtar* – [a] *Bhumiali*, *Pan*, *Pasi*, *Shikari*, etc. (Census, 1872). *Santhals* were the most dominant among the aboriginal tribes, while the '*Chandals*' were among the 'Semi-Hinduised Aboriginals', and also largest among the two groups.

The main professions in the ancient *Vanga* were agriculture and boating. The *Vanga* people grew transplanted rice. In a land of rivers, canals, swamps, dotted with innumerable islands, many lived in boats, which were used for all activities of life. They used boats in war and excelled in

nautical matters. The ancient non-Aryan Buddhist *Vangas* were masters of the seas. The *Chandals* or *Namasudra* were the descendants of the *Vangas* of Vanga Pradesh and dominated the region. The '*Chandals*' developed amphibious habit, grew large varieties of long-stemmed rice in the swamps and deep morasses. They developed a unique expertise in the reclamation of lands in the Sundarbans. They were excellent boat builders and excelled in boating. They were experts in navigation and nautical matters. In commerce, the main articles of trade were the finest of silk and muslin, Gangetic spikenard (*jatamansi*; medicinal plant) and pearls (Arthasastra 4th century BCE, Periplus/1st century CE). The silk and muslin manufactured in the *Vanga* (*vangaka*) region was a white and soft fabric (*dukula*); of Pandya manufacture (*pundraka*) it was black and as soft as the surface of a gem; of Suvarnakudya manufacture it was as red as the sun, as soft as the surface of the gem, woven while the threads are very wet, and of uniform (*chaturasra*) or mixed texture (*vyamisravana*). The cotton fabrics of Madhura, Aparanta, eastern parts of Kalinga, Kasi, Vanga, Vasta, and Mahisha were the best. Most of the Semi-Hinduised Aboriginal '*Chandals*' embraced Islam. In the Sundarbans, the indigenous inhabitants were the '*Pods*' and the '*Chandals*' who were mainly fishing tribes. Around 94% of the inhabitants of this area depend on agriculture.

Technology and products

The archaeological and literary evidences suggest that the agriculture in the region has been practiced from the pre-Aryan era by early settlers. As the water levels increased during the monsoon, canals were dug by the local people to divert water from rivers to fields. The region made significant contributions in the development of cultivation protocols for crop species adapted to high moisture levels. In this regard, cultivation of rice, jute, oilseeds, vegetables, spices have been unique. *Pundra* (one of the ancient names for the region) was well known for the cultivation of *dhanya* (paddy) and *tila* (sesame), which figure in the *Mahasthan* stone inscriptions, palaeographically assignable to circa 3rd century BCE. Inscriptions from the 8th century onwards occasionally record the plantation of both betel nuts (*guvaka*) and betel leaves (c.f. the term *barajika*, i.e., the grower/ seller of betel leaves), both of which must have been transacted. Coconut (*narikela*) plantations also figure in inscriptions of the same period, particularly in those coming from coastal tracts. In the *Chandikavya* of Mukundaram, there is a reference to *sadis*, and they were referred as *Kala pat-sadi* and *Agun-pat-sadi*. The term *pat* in Bengali means jute, thus, though there is no definite proof of jute cultivation in the ancient period, it is quite reasonable to infer that jute was known and cultivated in ancient Bengal

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(Dasgupta, 1941, as quoted by Niyogi, 2008) and therefore, might have contributed to its domestication and/or initial cultivation.

Rice, the most important crop of the region, is the staple food. The region has made significant contribution to global agriculture in rice by generating diverse production systems and genetic diversity suited to diverse and difficult ecologies. Evidence for storage of rice grain comes from the earliest reference of rice granary in Bengal, found in the *Mahasthan Brahmi* inscriptions of the Maurya period. It was located in *Pudanagala* (Pundranagara). Rice has also been referred in Buddhist Jatakas. Kalidasa's *Raghuvamsa* contains a reference to rice cultivation in Bengal. He also refers to a specific variety called *swastika,* which means a variety that was maturing in 60 days. Writings such as *Paryayaratnamala* also recount paddy cultivation in Bengal. According to one scholar in these writings, 119 varieties of rice were grown in 24 Parganas (Dey, 1926). The *Amarakosa* refers to three varieties of paddy – *kalama*, *swastika*, and *asuvrihi* (Niyogi, 2008). Pusa Niyogi (2008) presents a list of 104 paddy varieties (listed by Ramai Pandit in the *Sunya Purana*), plus 61 (listed by Rameswar in *Sivayana*), and classified lists of 16 + 31 paddies cultivated in different parts of ancient Bengal, giving an idea about the amount of genetic diversity evolved by the local farmers to meet the demands of various agroecologies and consumers.

Dr Debal Deb reports more than 5,500 varieties from Bengal (Deb, 2000). These region-specific varieties termed as 'folk varieties', express wide variation in their characteristics. They can be short-duration to long-duration, fine to bold, and have diverse numbers of grains per spike (*Jugal*, the double-grain rice, and *Sateen*, the triple-grain rice; published and copyrighted by Deb, 2005), purple rice (*Khara*), high-yielder (5–6 t ha^{-1}) to low-yielder, scented to non-scented, etc. Numerous local rice landraces show marked resistance to insect pests and pathogens. *Kalo nunia, Kartik-sal*, and *Tulsi manjari* are blast-resistant. *Bishnubhog* and *Rani kajal* are known to be resistant to bacterial blight (Singh, 1989). *Gour-Nitai, Jashua*, and *Shatia* seem to resist caseworm (*Nymphula depunctalis*) attack; whereas, on *Khudi khasa, Loha gorah, Malabati, Sada Dhepa,* and *Sindur mukhi* stem borer (*Tryporyza* spp.) attack is seldom observed (Deb, 2009). For these reasons and tolerance to salinity, Dr Deb commented that folk varieties are the best, particularly under low-input and adverse conditions.

As per the ecological adaptation, rice can be grown on marginal land like deep water to dry scanty rainfall areas, etc. Traditional farmers grow rice varieties as per their specific adaptations to the local environmental and soil conditions. *Rangi, Kaya, Kelas*, and *Noichi* are grown on rainfed dryland farms, where no irrigation facility exists. Late or scanty rainfall does not affect the yield stability of these varieties. In flood-prone districts, *Sada Jabra, Lakshmi-dighal, Banya-sal, Jal kamini*, and *Kumrogorh* are grown, which tend to grow taller with the level of water inundating the field, because of their remarkable culm-elongation property. The deepest water that a variety can tolerate was recorded to be 6 m in *Lakshmi-dighal*.

Getu, Matla, and *Talmugur* can withstand up to 30 parts per thousand (ppt) of salinity, while *Harma nona* is moderately tolerant to salinity (Deb, 2009). No modern rice variety can survive in these marginal environments. As per Cleveland *et al.* (2000), traditional crop varieties are often recorded to out-yield modern varieties in marginal environmental conditions.

Under traditional cultivation, the rice is cultivated on high, middle, and lowland, and the farmers have evolved varieties suited to these conditions. For example, on highland, *aus* varieties like *Ashinlaya, Kalas, Kaya* with short-duration maturity (90 to 100 days) are cultivated. *Kalas, Kaya* are also tolerant to drought and resistance to several diseases. Whereas, on middle lands that are flooded for long duration, long-duration varieties like *Nona* or *Kalamkatti*, maturing in 150 to 180 days, and on lowlands with standing water, varieties like *Doharlagra* are cultivated.

The specific agroecology of excessive water during the rainy season and ingress of salinity from the sea has generated a great deal of genetic diversity for traits such as submergence tolerance, tolerance to salinity, and deepwater floating types, in the districts of Medinipur, Birbhum, Hoogly, Howrah, and 24 Parganas (Siddiq *et al.,* 2006). Two groups of deepwater rice occurring in the region are *Rayada* and *Ashina.* The winter varieties, known as *Aman*, grown by the broadcast method, have the capacity to elongate their internodes in response to rising water levels; they are also cultivated in deepwater ecologies (Cai and Morishima, 2000). A series of varieties of *Boro* rice for winter cultivation in rainfed swampy areas or low-lying or medium lands with irrigation during November to May, and submergence-tolerant rice varieties has also been evolved. *Boro* is a Bengali word derived from the Sanskrit *Borob*, which means a special type of rice cultivation on residual or stored water in low-lying areas after the harvest of *kharif* rice. All this genetic diversity has been extensively used in breeding programs for the development of aromatic rice varieties suited to these areas.

Evidence for storage of rice grain comes from the earliest reference of rice granary in Bengal, found in the* Mahasthan Brahmi *inscriptions of the Maurya period.

Most non-aromatic local folk varieties, including *Boro* and submergence-tolerant rice, represent a high degree of genetic diversity. For example, varieties such as *Jalaplabhan* and *Jaldhi* are known from North Parganas for tolerance to flood; *Nona Bokra* and *Rupsali* for tolerance to salt; and *Patnai* for red glutinous grain. Other non-aromatic extant varieties are *Badkalamkati*, *Bhasmanik*, *Charnock*, *Churank*, *Ohairal*, *Dular*, *Latisil*, MC 282, *Nonabokra*, *Nonarasmsail*, *Nizersail*, *Patanai* 23, *Seethasail*, *Jayanthi, Ratna, Krishna, Cauvery, Supriya,* etc. Folk varieties such as *Jaya, Rasi, Vani, Surekha, Sonamukhi, Lal Basmati,* and *Eswaramangallam* have been identified with resistance to diseases, and have been extensively used in breeding programs to develop varieties suited to diverse agroclimates/areas.

There are at least 42 scented extant varieties grown by indigenous farmers in the region (Deb, 2005). For example, *Tulsi Mukul* and *Danagoori* in Bankura district are used to prepare a special type of pudding. Other common scented varieties are *Gopal bhog, Govind bhog, Kammini bhog, Randhumipagal, Seeta bhog, Kataribhog, Badshahpasand,* and *Badshahbhog. Kalijira* is the most prized exotic long-grain variety in the region, extending to Orissa and Bangladesh. In Bengali, *kalijira* means 'black (*kali*) cumin (*jira*)', as the un-hulled rice grain is black and resembles black cumin seeds. It is very popular in local cuisine. Some of the rice varieties commonly grown in the Bangladesh region are *Chinigura* and *Kalijira* – similar to basmati and jasmine rice but with very tiny, short grains, resembling sushi rice; others are *Kataribhog, Paijam, Najirshail, Balam, Binni, Brri Dhan, Hori Dhan, Miniket, Hamim*, etc. (Chowdhury, 1996).

A few rice varieties have unique therapeutic properties. For example, *Parmai-sal* is believed to have special nutritional value. *Kabiraj-sal* (*kabiraj,* means village doctor) is another variety fed to convalescing patients for quick recovery. The pink starch of *Kelas* and *Bhut moori* is an essential nutrient for tribal women during and after pregnancy. The tribal people believe it heals their anemia, because of high iron content and folic acid in the grains. Local food cultures hold *Dudh-sar* and *Parmai-sal* in high esteem because they are "good for children's brains" (Deb, 2005). In addition, the region also has genetic variability in the form of a wild tetraploid species, *Porteresia coarctata* (Roxb.) Takeoka (*Oryza coarctata*) found in the tidal swamps of the Sundarbans (SD Sharma, personal communication).

After the Green Revolution, the folk varieties with valuable features have been fast dwindling, causing severe genetic erosion and homogenization with high-yielding varieties. Only a handful of folk rices have remained in farmers' fields (Deb, 1999). For the conservation of folk varieties, Dr Debal Deb initiated a conservation program in 1997, at Basudha of Bankura District, and established an institution called *Vrihi* (Sanskrit for rice), with 690 folk varieties, the largest nongovernmental seed bank in eastern India, and has characterized 416 of them (Deb, 2005). Following this, Mr Anupam Paul of Agricultural Training Centre, Fulia (Phulia), Nadia (with 205 folk rice varieties), Mr Avra Chakraborty at Ausgram Block, Burdwan, and Mr Sourin Chaterjee, also initiated conservation of folk varieties. As many traditional varieties have out-yielded the modern high-yielding varieties in farm experiments (Deb, 2009), farmers too have realized the importance of conservation and have found in the 'folk varieties' an effective alternative to input-intensive modern rice varieties. For example, *Keralasundari* gives 4–5 t ha^{-1}, which is higher or same as the popular modern variety (interview by Dr Debal Deb, 2010). Though wheat is not a major crop in the region, there are some landraces of wheat known from the region, such as *Hard Red Calcutta*.

In oilseeds, the *Jatakas* mention sesame, while the *Amarakosa* mentions linseed and black mustard, besides sesame. Eastern

India is one of the secondary centers of diversity for rapeseed mustard. A significant variability has been recorded in *yellow sarson*, where dwarf and early types with pendulous siliqua has been collected, particularly from the Indo-Bangladesh border areas. In *Brassica rapa* ssp. *toria*, Agrani (B54) is a selection from a local collection, and in the case of *B. rapa* ssp. *yellow sarson*, Benoy (B9) is derived from a landrace of Karimganj material, and Jhumka (NC1) single-plant selection from a local material from Nadia. The local landraces of *B. juncea* are *Jatai rai*, *Desi rai*, *Maghi rai,* etc. Of these, *Jatai rai* is resistant to Alternaria blight. Several other varieties have been derived through selection, for example, *Seeta* from a landrace of *Puva Medinipur* in *B. juncea* (Kumar *et al.,* 2004). In pea, variety Dhusar is a selection from the local material.

Several historical documents (Ain-e-Akbari by Abul Fazal in 1590) indicate traditional cultivation and use of the white *capsularis* jute for cloth in Bengal. *Tossa*, the *olitorius* jute, is an introduced Afro-Arabian variety well adapted to the region, which has softer, silkier, and stronger fiber than white jute. The *capsularis* varieties cover 60 per cent of the area, whereas the *olitorius* varieties cover 40 per cent of the area, and the region is known for genetic diversity. Consequently, the Central Research Institute for Jute and Allied Fibres (CRIJAF), Kolkata and the Bangladesh Jute Research Institute (BJRI) has been able to collect around 2,500 and 4,100 accessions respectively from the region (Chowdhury 1996; Saha *et al.,* 2004). These collections have resulted in the development of a number of varieties both in *white* and *tossa* jute with diverse characteristics suited to various agroecological conditions of the region. In the case of white jute varieties, such as *Sonali, Sabuj sona* (JRC212, a selection from local landrace), *Shyamali* and 'D 154', an old standard variety, originally selected in 1918, from '*Kakya Bombai*', have been developed. Similarly, in *tossa* jute, *Baisakhi tossa* (JRO632, a selection from a local landrace), and *Chaitali tossa*, *Basudev*, *Chinsurah green* and *Navin* are other varieties developed. About 1,090 landraces of *deshi* jute (*Corchorus capsularis*) and 519 of *tossa* jute (*C. olitorius*) were reported scattered throughout the land mass of Bangladesh (Chowdhury, 1996). In addition, genetic resources are available in the form of wild jute, such as *Corchorus aestuans* L. (syn. *C. trilocularis* L.; *Tita Pat* or East Indian mallow). The *Aryasaptasati* describes the rows of hemp plants (*sana-sreni*) standing in a field of yellow flowers. Sugarcane and cotton were important products of ancient Bengal, with similar levels of variability as that of upper and middle Gangetic plains. Sugarcane was produced in some parts of ancient Bengal and referred as *Paundraka* by Sushruta. The distribution of cultivated *Saccharum barberi* and *S. spontaneum* extends from Dehradun to West Bengal in the Indo-Gangetic plains.

The region grew a number of vegetables: the *Paryayaratnamala* refers to two varieties of garlic, onion with two forms – red and white, *patola*/*paraval* (*Trichosanthes dioica*), *olla* (*Arun indicum*), *sobhanjana* (*Moringa pterygosperma*), *kecuka* (*kacu*, a variety of *kanda*), *sthalakanda* (*vena olakacu*), *ervaruka*

or *karkatika* (*kahkunda*), beans – white and black (*simba*), pumpkin, *karavellack* (bitter gourd), *kusmandake* (a gourd), *vartaku* (brinjal), etc., and spices such as cumin (black, white and small), cardamom and coriander, while the *Saduktikarnamrta* refers to *javani*, *satapuspika* (aniseed), and *kustumbari* (coriander), *ela* (cardamom) was referred in the *Ramacharita* (Niyogi, 2008) and evolved a large amount of genetic variability. *Solanum melongena* was domesticated in the Indo-Myanmar region, and presents significant level of variability. In okra, the region is considered one of the major centers of maximum variability for fruit and plant morphotypes along with the wild relative *Abelmoschus crinitus*. The variety Pusa Makhmali, which is the parent of Pusa Sawni, one of the most popular Indian varieties, was derived from a landrace from West Bengal (Dhankhar *et al.,* 2005). In cucurbits, *Trichosanthes anguina* is widespread, *Momordica cochinensis* is very popular, while *M. dioica* is cultivated. In spices, the region is known for genetic variability in ginger and turmeric. Betel vine is a traditional commercial crop of the region.

There are at least 42 scented extant varieties grown by indigenous farmers in the region. For example,* Tulsi Mukul *and* Danagoori *in Bankura district are used to prepare a special type of pudding. Other common scented varieties are* Gopal bhog, Govind bhog, Kammini bhog, Randhumipagal, Seeta bhog, Kataribhog, Badshahpasand, *and* Badshahbhog. Kalijira *is the most prized exotic long-grain variety in the region, extending to Orissa and Bangladesh.

The *Ramacharita* (Nandi, 1939) mentions many trees, flowering plants, and medicinal plants, including mango, which offers a large number of traditional varieties, such as *Bombai*, *Himsagar*, *Kishen Bhog*, *Langra*, and *Malda*; banana presents traditional varieties such as *Dwarf Cavendish*, *Pooran*, and *Rasthali*; and bael, with varieties such as *Ojha*, and *Azamati*; whereas jackfruit (*Artocarpus heterophyllus*) and *Carissa carandas* of the region are known for their quality fruit and plant characteristics.

In livestock, the farmers of West Bengal have evolved and conserved precious germplasm of Black Bengal Goat, a small breed of goat found in the region. It has natural resistance to several diseases, but is vulnerable to cold, waterlogging, diarrhea, ecto- and entro-parasitic infestation and respiratory diseases (Nandi *et al.,* 2011).

Because of being inundated for most time of the year, the floodplains and the delta region offers very rich aquatic diversity. Fish genetic resources with approximately 300 species of fresh and brackish water fish species in Bangladesh alone – the third largest in aquatic biodiversity in Asia (Hussain and Mazid, 2001) – is attributed to the habitat offered by the world's largest wetlands of the LGP (Bengal Delta), formed by three large river systems, Brahmaputra, Ganges, and Jamuna. Hamilton (1822) published fishes found in the river Ganges and its branches. More than 40 types of fish (mostly freshwater) are common in the Indian region, including carp varieties

such as *rui* (*rohu*), *koi* (climbing perch), the wriggling catfish family of *tangra*, *magur*, *shingi* and the pink-bellied Indian butter fish, the *pabda katla*, *magur* (catfish), *chingri* (prawn or shrimp), as well as *shutki* (small dried sea fish). *Chingri* could be *kucho* (varieties of shrimp), *usual* (prawns), *bagda* (tiger prawns), and *galda* (Scampi). Saltwater fish (not sea fish), hilsa (*hilsa ilisha*) is very popular from the region. *Ilish machh* (hilsa fish), which migrates upstream to breed, is a delicacy; the varied salt content at different stages of the journey is of particular interest to the connoisseur, as is the river from which the fish comes, the river *Pôdda* (Padma or Lower Ganges) in Bangladesh. *Shad* or *herring* is a close relative of *hilsa*, locally known as *ilish*, and is an addiction among Bengalis.

Future perspective

One of the greatest challenges the people living on the Ganges Delta would face in coming years is the threat of rising sea levels, caused mostly by subsidence in the region and partly by climate change, and needs research attention for improved management of coastlines, adopting suitable strategies (mangrove intensification).

After the Green Revolution, the folk varieties with valuable features have been fast dwindling, causing severe genetic erosion and homogenization with high-yielding varieties. Only a handful of folk rices have remained in farmers' fields.

The dense human population is ever-growing with urbanization, industrialization, and agriculture, posing serious threats to the remaining forest fragments. The small, protected areas are vulnerable to conserve the ecoregion's biodiversity. People living in these reserve areas largely depend on the forest and its resources, and therefore a participatory conservation approach is needed. Aquaculture practices, excess fishing and harvesting of timber and firewood are some of the major threats to the reserves. Therefore, the existing protected areas need to be effectively managed by restoring critical habitat wherever necessary, and meeting the demands of the local people to sustain livelihoods.

The region is very rich in aquatic and floristic diversity, particularly in mangrove forests. But it is being lost at a rapid pace, therefore sustainable aquaculture and conservation of fish species needs attention. Similarly, the farmers' varieties, particularly in rice are being eroded with the introduction of high-yielding varieties, and with them there is an erosion of genes conferring many of the desirable features, such as tolerance to submergence and ingress salinity, and traits associated with yield-reducing factors and nutritional quality. They need protection and popularization among the farmers under participatory breeding programs for inbuilt resilience/flexibility to changing climate and the ability to provide comparable yields under low-input conditions. This would promote sustainable agriculture with conservation of valuable genetic resources.

Fish farming has emerged as an important source of livelihood for farmers. The species of domestic fishes such as *rohu*, *katla*, *bata* have a major demand in West Bengal as they constitute the major consumable food items among the masses. Fish farming therefore needs to be promoted and integrated with field agriculture, and crops such as rice, jute, coconut, etc.

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