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Probable Agricultural Biodiversity Heritage Sites in India: XXI. The Malabar Region[1]

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Abstract

Malabar, the southwestern coastal region of India, is the wettest and biodiversity-richest region in the country. Agriculture has been practiced in the region from ancient times, involving the majority of the people. The ingenuity of the people in evolving agriculture is reflected in the extensive water management system, the backwaters in the low-lying areas of the coastal region, and in harmoniously using the conditions for wet cultivation of rice by developing systems such as 'pokkali' *and* 'kaipad', *and 'home garden' suiting to the tropical conditions of the region. Further, the region can be credited for the domestication and introduction of a number of crop species from different parts of the world, enriching its agrobiodiversity. Its rich spice-diversity has led to the region being called the 'land of spices'. Cultivation of enriched agrobiodiversity under diverse agroecosystems and production systems has generated rich genetic diversity in most crops, to the extent that the region has been considered one of the secondary centers of diversity for rice, primary center of origin and diversity for black pepper, cardamom, cinnamon, jackfruit, etc., and important center of diversity for several other crops such as turmeric, ginger, bitter gourd, banana, etc. For these contributions of the local communities, providing livelihood support and conserving genetic diversity in a large number of crops, the region is being proposed as another National Agricultural Biodiversity Heritage Site. The present article discusses some of these contributions in brief.*

The Malabar region is a long and narrow coastline on the southwestern shore of the Indian subcontinent. It is part of the recently (2012) recognized UNESCO World Heritage Site, the Western Ghats, and comprises the wettest regions of southern India with the richest biodiversity, and therefore offers very congenial conditions for agriculture and related activities. Because of these reasons the majority of the population has been involved in diverse agricultural activities from ancient times. Globally, the region was known as the land of spices. Like the neighboring Konkan region, it was another major Indian trading hub having commercial interactions with other parts

1. This is the last paper in the series on "Probable agricultural biodiversity heritage sites in India" published in Asian Agri-History.

of the world, such as China, Mesopotamia, Egypt, Greece, Rome, Jerusalem, Persia, and Arabia from ancient times. The region has several old and still functional port cities, which have been the centers of global trade and which played an important role in the introduction of exotic crops into India, enriching the plant agrobiodiversity. The region is credited for the development of a unique system for the management of the excessive water and backwaters (created by high rainfall and the tides and flash flooding of sea water into the mainland in the coastal areas), with a chain of networks of both natural and man-made water channels (canals) and meticulously using them for transport and productive upland and aqua agriculture. The local communities have further utilized the situation with ingenuity for ecofriendly farming by developing harmonious and unique tropical wet cultivation systems of rice, such as '*pokkali*' and '*kaipad*', with the selection of salinity- and submergence-tolerant rice landraces/varieties for cultivation in saline water and below the sea level, and suiting to diverse agroecosystems of the region, thereby evolving and enriching the rice genetic diversity to the extent that the region is being proposed for another secondary center of diversity. These systems are being further enriched with the integration of aquaculture of rice–shrimp/prawn farming. Similarly, the positive interaction of local communities with horticultural crop species and the undulating, hilly, and slopy terrain with high rainfall has resulted in the domestication of several species, particularly the one with spice properties and development of a number of unique tropical agricultural/farming systems with diverse mixed cropping in canopies, with tree species such as coconut in the first canopy, and herbaceous ginger, turmeric, pineapple, vegetables, grasses, etc., in the last, as basal crops, enriching the agrobiodiversity and generating genetic diversity, particularly in cash crops like spices and providing new avenues to the local people for livelihood support both at farm and home garden level. For these contributions – evolving natural resource management and sustainable agricultural systems, enrichment of crop diversity with domestication of indigenous economic species, and introduction of exotic crops and genetic diversity with their cultivation under diverse agroecosystems/production systems of prevailing wet micro-agroclimatic conditions, and their conservation – the region is being proposed as another National Agricultural Biodiversity Heritage Site based on the indices described by Singh and Varaprasad (2008).

Location and extent

In the ancient times, the term *Malabar* was used to denote the entire southwestern coast of the Indian peninsula. Today it refers to the Malabar region, which broadly consists of parts of the coastal plain of Karnataka and most of Kerala, between the Western Ghats range and the Arabian Sea (Fig. 1). As per the present administrative boundaries, the region extends over the coastal Dakshina Kannada, Kodagu, and Mysore districts of Karnataka, all the districts of Kerala, and parts of the bordering Western Ghats mountain districts of Tamil Nadu, Udhagamandalam (Nilgiri), and Kanyakumari (Fig. 1).

Figure 1. Location and extent of the Malabar region.

Landscape

The landscape of the region is characterized by an asymmetrical topography that includes lowlands bordering the sea, the midlands dominated by undulating subdued hills and steep scarp slopes and forests, and the highlands on the east, in parts of the Western Ghats. The altitude ranges from below mean sea level to 2694 meters above mean sea level. The highest peaks of the Western Ghats, Anamudi (2695 m) and Dodabetta (2636 m) are part of the region. The region is well-drained by many streams and rivers because of the undulating topography of most of the areas. The coast presents a continuous belt of sand dunes, behind which lie many lagoons paralleling with the coast and linked by canals to form inland waterways.

One of the unique and delightful landscapes that have come to exist in the region are the backwaters. These are a chain of brackish lagoons and lakes lying parallel to the Arabian Sea coast (the Malabar Coast), and extending to half the length of the region in Kerala. The five large lakes of the backwaters are linked by natural and man-made canals, which are fed by 38 rivers. The backwaters were formed by the action of waves and shore currents creating low barrier islands across the mouths of many rivers flowing down from the Western Ghats range. In the midst of this landscape there are a number of towns and cities that serve as the starting and end points of backwater cruises. The backwaters offer a unique aquatic biodiversity including crabs, frogs and mudskippers, otters, turtles, and water birds such as terns, kingfishers, darters, and cormorants. The very rich flora lends a green hue to the surrounding landscape, which includes palm trees, *Pandanus* shrubs, various leafy plants, and bushes.

Agroclimate

The Malabar region is a hot, humid-perhumid ecoregion. The climate is humid with tropical monsoon and is characterized by hot to mild summers, a long rainy season and very mild short winters. Geographically, the region represents the wettest regions of southern India, in which the Western Ghats intercept the moisture-laden monsoon clouds to bring rain, especially on their westward-facing mountain slopes. Thus, most of the region's average annual precipitation exceeds 2000 mm, which is incessant and comes in varying amounts throughout the year, firstly because of the southwest monsoon from June to September (experiencing heavy rainfall), followed by the northeast monsoon, which sets in during October and November. The rainfall covers the entire annual potential evapotranspiration. However, due to seasonal dry spells, especially during February to April, there may be some moisture-deficit affected areas. For these reasons, the region facilitates a long growing season, which may extend to more than 270 days. In addition, there is availability of abundant water due to the extensive network of rivers, streams, lakes, and backwaters to facilitate agricultural activities. The region experiences a mild winter during the months of December to February. The temperature during summer (March to May) ranges between 29°C and 39°C. It remains low during the rest of the year, due to incessant rains. During winters,

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the maximum temperature is 25°C and the minimum is 14°C.

Based on the morphological and physico-chemical properties, the soils of the region are divided into ten groups. However, the major soils are red loams, lateritic soils, and the alluvium-derived soils in the coastal plains. The soils are deep, clayey, profoundly to moderately acidic in nature and are poor in base saturation.

Floristic diversity

Being part of one of the global biodiversity hotspots, the Western Ghats is recognized as a World Heritage Site by UNESCO for being an "Evolutionary Ecotone", with exceptional levels of biological diversity and species endemism. The region is very rich in floristic diversity with 4681 flowering species belonging to 1415 genera and 188 families (Nayar *et al.,* 2006), and with unique and diverse microclimates support 1286 endemic species compared to about 234 in the Northern Western Ghats (Nayar, 1996). Ecologically, the region has been referred to as belonging to tropical and subtropical moist broad-leaf forests of southwestern India. However, the vegetation of the region varies with climatic, altitudinal, and other edaphic factors. The hilly zone contains maximum forests/vegetation, midlands only little, while the coastal regions have mostly mangroves. As per Champion and Seth's classification (2005), the natural vegetation comprises, tropical moist wet evergreen forests, tropical semi-evergreen forests, tropical moist deciduous forests, tropical dry deciduous, montane and shola forests. The top canopy of the **tropical wet evergreen forests** is represented by *Acrocarpus fraxinifolius* Wt. & Arn., *Artocarpus hirsutus* Lam., *Antiaris toxicaria* Lesch., *Calophyllum tomentosum* Wight, *Canarium strictum* Roxb., *Cinnamomum zeylancium* Bl., *Cullenia excelsa* Wight, *Dipterocarpus indicus* Bedd., *Dysoxylum malabaricum* Bedd. ex Hiern, *Michelia champaca* L., *Mesua ferrea* L., *Palaquium ellipticum* (Dalz.) Baill., *Tetrameles nudiflora* R.Br., *Vateria indica* L., etc. The **tropical semi-evergreen forests** include species, like *Alstonia scholaris* (L.) R.Br., *Artocarpus hirsutus, Hydnocarpus pentandra* (Buch.-Ham.) Oken, *Knema attenuata* (J.Hk. & Th.) Warb., *Sterculia guttata* Roxb., *Terminalia paniculata* Roth, etc. The **tropical moist deciduous forests** consist of *Adina cordifolia* (Roxb.) Hook. f., *Albizia amara* (Roxb.) Boivin, *Bombax ceiba* L., *Dalbergia latifolia* Roxb., *Dillenia pentagyna* Roxb., *Ficus glomerata* Roxb., *Kydia calicyna* Roxb., *Lagerstroemia lanceolata* Wall., *Macaranga peltata* (Roxb.) Müll.Arg., *Pterocarpus marsupium* Roxb., *Tectona grandis* L.f., etc. The **tropical riparian forests** consist of *Calophyllum apetalum* Willd., *Garcinia gummigutta* (L.) Roxb., *Homonoia riparia* Lour., *Ochreinauclea missionis* (Wall. ex G. Don) Ridsd., *Holigarna arnottiana* Hook. f., etc. The **tropical hilltop forests** consist of *Cullenia exarillata* Robyns, *Elaeocarpus serratus* L., *Mesua ferrea, Gluta travancorica* Bedd.,

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etc. The **tropical dry deciduous forests** consist of *Acacia* Mill. spp., *Azadirachta indica* A. Juss., *Butea frondosa* Roxb., *Cassia fistula* L., *Dalbergia paniculata* Roxb., *Sterculia urens* Roxb., etc. The **montane wet semi-temperate forests** in the sholas are represented by species such as *Ilex wightiana* Wall. ex Wt., *Michelia nilagirica* Zenk., *Vaccinium leschenaultia* Wt., *Rhodomyrtus tomentosa* (Aiton) Hassk., *Eurya nitida* Korth., etc.

Agriculture and agricultural biodiversity

Broadly based on micro-agriculture characteristics, the region has two zones, the northern Malabar Coast and the southern Malabar Coast. The terrain of the region is heterogeneous with varied topography and heavy rainfall, which causes flash flooding and inundation in the coastal areas. Thus, because of the location and altitudinal variations, the region has been blessed with a wide range of agroecological conditions, which can be divided into three broad zones: the hilly zones with slopes (highland), the midlands, and the coastal zones (lowland). The agriculture and agricultural practices have evolved as per these variations in climate, altitude, and the edaphic conditions. Nayar (2011) counted 142 crops belonging to 43 families and 104 genera in Kerala. Rice is the staple food and the main crop. Other crops are coconut, banana, mango, cashew, black pepper, arecanut, cardamom, vanilla, cinnamon, ginger, turmeric, nutmeg, clove and commercial crops such as rubber, tea, and coffee.

Tea, coffee, and cardamom are predominantly cultivated in the highlands. Teak and rubber are cultivated in the lower slopes of the highland region. The midlands are mainly occupied by coconut palms, with paddy, tapioca (cassava), pepper, pineapple, and pulses. Banana, ginger, and rubber are also grown in the midlands. However, rubber, coconut, and tapioca are predominantly grown at low elevations under humid-tropical conditions. In the laterite dry zone, tapioca used to be cultivated and was the second most important crop and major food of the region, occupying around 10% of the cultivated area; however, now it is replaced by rubber.

There are three major cropping systems, based on the primary crop and way of cultivation:

1. Coconut-based cropping systems: In this system, coconut is the major crop intercropped with crops such as pepper, arecanut, cocoa, banana, turmeric, ginger, small tubers, and fodder, and in some areas with upland rice, pulses, and oilseeds (Fig. 2).
2. Rice-based cropping systems (particularly in lowlands): Either a single or two crops of rice are grown, depending on the availability of water, as in the central area of the region, or

after dewatering of impounded water, as in the *kayal* lands of Kuttanad. In some areas, vegetables, pulses, and oilseeds are grown in fallows or as summer crops (Fig. 3). Fish farming or prawn culture is practiced, after the rice crop, in the coastal areas of water inundation.

3. Homestead farming systems: The traditional system of home garden, as per the agroclimatic conditions, favors growing of a wide variety of crops (Fig. 4). In this system, farmers choose their crop combinations and livestock or fish farming as per the prevailing conditions.

Figure 2. Coconut-based cropping system (Source: www.coconutboard.nic.in).

Rice cultivation traditionally occupies the pride of place. It was cultivated in almost all parts of the region in all three seasons: in *Viruppu* (*kharif*/autumn/first crop season) April–October, in *Mundakan* (*rabi*/winter/second crop season) October–January, and in *Puncha* (summer/third crop season) January–April. Taking into consideration the topography, soil, and abiotic factors and seasonal differences, rice is grown in eight distinct agroecosystems (Nair, 2000, as cited by Leena Kumari, 2012), including the *pokkali* system (see p. 332). Based on four parameters – altitude, rainfall pattern, soil type, and topography – the Kerala area has been delineated into thirteen agroclimatic zones: Onattukara, Coastal sandy, Southern

Figure 3. Rice-based production systems (Source: Sasidharan *et al.,* Kerala Agriculture University, 2012).

Figure 4. Homestead garden in Wayanad (left) (Source: www.pappysnet.com); traditional coffee-based homestead garden with pepper (right) (Source: A V Santoshkumar).

midlands, Central midlands, Northern midlands, Malappuram type, Malayorum, Palakkad plains, Red loam, Chittoor black soil, Kuttanad, Riverbank alluvium, and High ranges. In these zones, rice is cultivated in the following distinct cropping systems: (1) rice–rice–legumes/rice–rice–sesame/rice–rice–vegetables; (2) rice–rice–fallow; (3) rice–prawn/rice–fallow; (4) rice–rice-fallow/rice–rice–vegetables; (5) fallow rice–fallow; (6) rice–rice–fallow/rice–rice–vegetables; (7) rice–rice–vegetables; (8) rice–rice–legumes; and (9) rice–rice–water fallow rice–fish (Leena Kumari, 2012). The important rice varieties cultivated in Kerala are *Jyothi, Rohini, Annapurna, Triveni, Jaya, Aswathy, Sabari, Bharathy, Mahsuri, Navara, Ponni,* and *Samba,* while the important rice varieties in Dakshina Kannada, Kodagu, and Mysore are *Annapurna, Mangala, Jaya, Puspa, Madhu, Pankanj, Vani, Sona, Pakash,* and *Phalguna*. In recent times rice is being replaced with other remunerative crops.

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'Home gardens' comprise a significant portion of the agricultural sector of the region, catering to the subsistence needs of farmers' families. Nearly 50% of the holdings falling in this category belong to the marginal farmers (FIB, 1992). This system has high-density farming involving several species of seasonal, annual, and perennial crops to meet the household demands and to achieve highly efficient use of resources. The crop components in 'home gardens'

are influenced by the climate, household preferences, requirements, and dietary habits. Under home gardens, coconut-based cropping system is predominant to most of the agroclimate, except in the high ranges. An array of intercrops is raised, resulting in a multistory cropping pattern with canopy stratification. Perennial tree crops such as coconut, arecanut, jack, mango, cashew, tamarind, and forest tree species occupy the upper layer; pepper, clove, nutmeg, cinnamon, cocoa, etc. occupy the second layer; banana, cassava, yam, cocoyam, etc. occupy the third layer; and ginger, turmeric, pineapple, vegetables, grain legumes, and guinea grass occupy the ground layer (Fig. 4). This nearly approaches the tropical rainforest structure and species diversity (Shehana *et al.,* 1992).

Animal husbandry is also an important activity, which has been integrated with other farming systems and has been considered a means for poverty alleviation among marginalized and landless farmers, and unemployed women. Therefore, the home gardens of the region often combined with livestock rearing, interacting synergistically for sustained productivity (Salam and Sreekumar, 1990). Cows, buffaloes, goats, poultry, pig, etc. are the common livestock components as per the prevailing environmental conditions and situation. As per Salam *et al.* (2008), based on biological and physical factors, the following home garden systems are common in the region:

1. Involving uplands with crops only;
2. Involving uplands with crops and livestock;
3. Involving uplands associated with adjoining lowlands with crops only;
4. Involving uplands associated with adjoining lowlands with both crops and livestock;
5. Involving uplands with adjoining backwaters with crops, livestock, and agro-based industries.

Commercial/cash crops are the major constituents of the agriculture and agrobiodiversity, and play an important role in the economy of the region. The main cash crops are spices, coconut, rubber, tea, coffee, arecanut, cashewnut, ginger, etc. The region is traditionally the main producer of spices, which together form the number one cash crop. The region has been known for the trade of spices for more than three millennia, and is geographically associated with the fresh aroma of superb-quality spices. This has lured foreigners into the country since as early as in the Medieval Age. The region produces 96% of the pepper in India. The other important spices are cardamom, cinnamon, clove, turmeric, nutmeg, ginger, and vanilla. Cardamom exports bring high revenues. Coconut occupies 25% of the cropped area and provides 70% of the Indian output. It provides not only the coconut fruit, the principal source of income, but also raw material for the coir industry and coconut shell for artifacts and handicraft. The region holds a monopoly with regard to rubber, accounting for 85% out of the total area under natural rubber in the country, and produces 91% of India's rubber. Kottayam district has extensive areas producing and processing rubber. The

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Kerala area is the single largest producer of banana also, occuping nearly 30% of the total cropped area.

Representative crop species in various crop groups

Cereals. *Chama* or little millet (*Panicum sumatrense* Roth), *cholam* (*Zea mays* L.), *koovaraku* or finger millet [*Eleucine coracana* (L.) Gaertn.], *nellu* or rice (*Oryza sativa* L.), and *varagu* or kodo millet (*Paspalum scrobiculatum* L.). Apart from rice, the area under other crops has drastically reduced.

Grain legumes and oilseeds. *Cherupayar* or green gram [*Vigna radiata* (L.) R.Wilczek], *ellu* or sesame (*Sesamum indicum* L.), French bean (*Phaseolus vulgaris* L.), *kudzu* [*Pueraria phaseoloides* (Roxb.) Benth.], grown as cover crop in rubber estates, *muthira* or horse gram [*Macrotyloma uniflorum* (Lam.) Verdc.], *nilakkadala* or groundnut (*Arachis hypogaea* L.), *perumpayar* or cowpea (*Vigna unguiculata* L.), *thuvarappayar* or pigeonpea [*Cajanus cajan* (L.) Millsp.], and *uzhunnu* or black gram [*Vigna mungo* (L.) Hepper].

Fodder crops. *Karuka* or Bermuda grass [*Cynodon dactylon* (L.) Pers.], *kuthirappullu* or Guinea grass (*Panicum maximum* Jacq.), napier grass (*Pennisetum purpureum* Schum.), *pillipesara* [*Vigna trilobata* (L.) Verdc.], *Stylosanthes humilis* H.B.K. and *S. scabra* Vogel (recent introductions), etc.

Vegetables. Cauliflower [*Brassica oleracea* L. var. *botrytis* (L.) Metzg.] (recent introduction), *churakka* or bottle gourd [*Lagenaria siceraria* (Molina) Standley], cucumber (*Cucumis sativus* L.), *koval* or little gourd [*Coccinia grandis* (L.) Voigt; syn. *C. indica* Wight & Arn.], *kumbalam* or ash gourd (*Benincasa hispida* Thunb.), lablab bean [*Dolichos biflorus* Lin.; syn. *Lablab purpureus* (L.) Sweet.], *mathan* or pumpkin [*Cucurbita moschata* (Duch.) Poir.], *mulaku* or green chili [*Capsicum annuum* L.; syn. *C. annuum* var. *frutescens* (L.) Kuntze.], oriental pickling melon (*Cucumis melo* L. var. *acidulus*), *muttakose* or cabbage (*Brassica oleracea* L. var. *capitata* L.), *padavalam* or snake gourd (*Trichosanthes anguina* L.), *paval* or bitter gourd (*Momordica charantia* L.), *peechanga* or ridge gourd [*Luffa acutangula* (L.) Roxb.], *seemachakka* or bread fruit [*Artocarpus altilis* (Park.) Fosberg] – unripe fruit used as vegetable, *sonjna* or drumstick (*Moringa oleifera* Lam.), spine gourd (*Momordica dioica* Roxb. ex Willd.) from

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wild, sponge gourd (*Luffa cylindrica* Roxb.; syn. *L. aegyptiaca* Mill.), sword bean [*Canavalia gladiata* (Jacq.) DC.], *thakkali* or tomato (*Lycopersicon esculentum* Mill.; syn. *Solanum lycopersicum* L.), *vazhuthana* or brinjal (*Solanum melongena* L.), *venda* or *bhindi* [*Abelmoschus esculentus* (L.) Moench], and yardlong bean [*Vigna unguiculata* Walp. var. *sesquipedalis* (L.) H.Ohashi]. Leafy vegetables: *cheera* or amaranthus (*Amaranthus cruentus* L.; syn. *A. paniculatus* L.), Chinese spinach (*A. tricolor* L.), Malabar spinach (*Basella alba* L.; syn. *B. rubra* L.), *Sesbania sesban* (L.) Merr., and spleen amaranth (*Amaranthus dubius* Mart. ex Thell.). Roots, bulbs and tubers: carrot (*Daucus carota* L.), *cheenikizhangu* or sweet potato [*Ipomoea batatas* (L.) Poir.], *chembu* or *arvi* [*Colocasia esculenta* (L.) Schott var. *antiquorum* (Schott) Hubbard & Rehder.] – with several cultivars and morphotypes, *chena* or elephant-foot yam [*Amorphophallus paeoniifolius* (Dennst.) Nicolson; syn. *A. campanulatus* Decne., *A. bulbifer*], Chinese or giant taro [*Alocasia cucullata* (Lour.) G. Don], *A. macrorrhizos* (L.) G. Don], Chinese potato [*Solenostemon rotundifolius* (Poir.) J.K. Morton.], *kachil* or yam (*Dioscorea alata* L. and *D. bulbifera* L; syn. *D. sativa* L.), *koova* (*Maranta arundinacea* L.), lesser yam (*Dioscorea esculenta* Lour.), *maracheeni* or tapioca (*Manihot esculenta* Crantz), *mullangi* or radish (*Raphanus sativus* L.), *seemamullangi* or turnip (*Brassica rapa* L.), and *urulakizhangu* or potato (*Solanum tuberosum* L.).

Spices. Black pepper (*Piper nigrum* L.), cardamom [*Elettaria cardamomum* (L.) Maton], cinnamon (*Cinnamomum verum* J. Presl; syn. *C. zeylanicum* Blume), clove tree [*Syzygium aromaticum* (L.) Merr. & L.M. Perry; syn. *S. caryophyllata* Thunb.], ginger (*Zingiber officinale* Roscoe), Malabar tamarind [*Garcinia cambogia* (Gaertn.) Desr.; syn. *G. gummi-gutta*], mango ginger (*Curcuma amada* Roxb.), nutmeg (*Myristica fragrans* Houtt.), *Trachyspermum strictocarpum* L. (syn. *Carum strictocarpum* Clarke) (rare), turmeric (*Curcuma longa* L.; syn. *C. domestica* Valet.), and vanilla (*Vanilla planifolia* Jacks. ex Andrews; syn. *V. fragrans* Ames).

Fruits. Avocado (*Persea americana* Mill.), *Baccaurea courtallensis* (Wt.) Muell-Arg. (from wild), *Buchanania barberi* Gamble (edible fruits), *chakka* or jackfruit (*Artocarpus heterophyllus* Lam.), *cherunaranga* or lime [*Citrus aurantifolia* (Christm.) Swingle], custard apple (*Annona squamosa* L.) (rare), *Elaeocarpus oblongus* Gaertn., *E. serratus* L., *elantha* or jujube (*Zizyphus jujuba* Miller), guava (*Psidium guajava* L.), star gooseberry [*Phyllanthus acidus* (L.) Skeels] – accidental in home gardens, Indian gooseberry (*Emblica officinalis* Gaertn.; syn. *Phyllanthus emblica* Wall. ex Stapf.), *jamun* [*Syzygium cumini* (L.) Skeels; syn. *Eugenia jambolana* Lam.], *karaunda* [*Carissa macrocarpum* (Eckl.) A.DC., *C. macrophylla* Wall. ('Bonsai')], *khirni* [*Manilkara hexandra* (Roxb.) Dubard], *mahua* [*Madhuca bourdillonii* (Gamble) H.J. Lam, *M. longifolia* (Koenig) J.F. Macb. var. *longifolia*] wild, *malaunthiri* or bullock heart (*Annona reticulata* L.) – home gardens, mango (*Mangifera indica* L.), mangosteen (*Garcinia mangostana* L.), *Lansium domesticum* Correa, *munthiringa* or grapes (*Vitis vinfera* L.), *naranga* [*Citrus*

limon (L.) Burm. f.], papaya (*Carica papaya* L.), persimmon [*Diospyros nilagirica* Bedd., *D. bourdillonii* Brand., *D. malabarica* (Desr.) Kostel., *D. pruriens* Dalz.] – from wild, rambutan (*Nephelium lappaceum* L.), *sapota* [*Achras sapota* L.; syn. *Manilkara zapota* (L.) P.Royen], Spanish cherry (*Mimusops elengi* L.), *vazha* or banana (*Musa sapientum* L., *M. acuminata* Colla, *M. rosacea* Jacq; syn. *M. balbisiana* Colla), West Indies cherry (*Malpighia glabra* L.; syn. *M. punicifolia* L.), and wood apple (*Limonia acidissima* L.).

Plantation crops. Cashewnut (*Anacardium occidentale* L.), cocoa (*Theobroma cacao* L.), coconut (*Cocos nucifera* L.), coffee (*Coffea arabica* L.), *kamuku* or arecanut (*Areca catechu* L.), oil palm (*Elaeis guineensis* Jacq.) (recent introduction), rubber [*Hevea brasiliensis* Willd. ex A. Juss.) Mull. Arg.], tea [*Camellia sinensis* (L.) Kuntze], and *vettila* or betel vine (*Piper betle* L.).

Ornamentals. *Champak* (*Michelia champaca*), dwarf date palm (*Phoenix pusilla* Roxb.), *Elaeocarpus* L. spp. (tree), feather palm [*Arenga pinnata* (Wurmb) Merr.; syn. *A. saccharifera*], fishtail palm (*Caryota urens* L.), ixora (*Ixora coccinea* L., *I. notoniana* Wall. ex G. Don), jacaranda (*Jacaranda acutifolia* Humb. & Bonpl.; syn. *J. mimosifolia* D.Don), jasmine [*Jasminum grandiflorum* L.; syn. *J. officinale* f. *grandiflorum* (L.) Kobuski, *J. auriculatum* Vahl., *J. multiflorum* (Burm. f.) Andr., *J. malabaricum* Wight.], lily (*Lilium neilgherrense* Wight), *Millettia splendens* Wight & Arn. (tree), palm (*Arenga wightii* Griff.), *Pelargonium graveolens* L. Heritt., *Rhododendron arboreum* Roxb. ssp. *nilagiricum*, and water lily (*Nymphaea nouchali* N.L. Burman, *N. rubra* L.).

Medicinal and aromatic plants. *Arjun* (*Terminalia arjuna*), *Boehmeria malabarica* Wedd., *brahmi* [*Bacopa monnieri* (L.) Wettst.], *chittamruthu* [*Tinospora cordifolia* (Willd.) Miers], *kacholam* (*Kaempferia galanga* Linn.), *karinochi* (*Vitex negundo* L.), *kudangal* [*Centella asiatica* (L.) Urban], lemon grass [*Cymbopogon flexuosus* (Steud.) Wats. var. *coimbatorensis, C. martini* Roxb. var. *tofia*,], *narunandi* (*Hemidesmus indicus* L. R.Br.), *njavaral panikoorka* (*Coleus amboinicus* Lour.), *orila* (*Desmodium gangeticum* L.DC.), *pelipparuthy* [*Pergularia daemia* (Forsk.) Chiov.], *ramacham* [*Vetiveria zizanioides* (L.) Nash; syn. *Andropogon zizanioides* Linn.], *sarpagandhi* [*Rauvolfia serpentina* (L.) Benth. ex Kurz.], *sathappu/arutha* (*Ruta graveolens* Linn.), *sathavari* [*Asparagus racemosus* var. *javanicus* (Kunth) Baker. J. Linn.], *thippali* (*Piper longum* Linn.), *thulsi* (*Ocimum sanctum* L.; syn. *O. tenuiflorum* L.), *vallippala* [*Tylophora indica* (Burm. f.) Merrill.], and white dammar (*Vateria indica* L.).

Timber and bamboos. Timber: *Anjali* (*Artocarpus hirsutus*), *ebony* (*Diospyros ebenum* Koenig), *eetty* or Indian rosewood (*Dalbergia latifolia*), *irul* (*Xylia dolabriformis* Benth.), *kambakam* (*Hopea parviflora* Bedd.), *kadam* [*Haldinia cordifolia* Roxb. Ridsd.; syn. *Adina cordifolia*], *kattupunna* or *poon* (*Calophyllum polyanthum* Wall. ex Choisy), mahogany (*Swietenia mahogany* L.), Malabar mahogany [*Kingiodendron pinnatum* (Roxb. ex DC.) Harms],

perumaram or tree of heaven (*Ailanthus excels* Roxb.), *Pterocarpus marsupium* Roxb., rosewood (*Dalbergia volubilis* Roxb., *D. beddomei* Thoth., *D. travancorica* Thoth.), teak (*Tectona grandis* Linn.), *vella ayani* or *gurjun* (*Dipterocarpus indicus*), *vellamaruthu* or *kindal* (*Terminalia paniculata*), white cedar (*Dysoxylum malabaricum*, *D. beddomei* Hiern), and *Xylia xylocarpa* (Roxb.) W.Theob. Bamboo: *Dendrocalamus strictus* (Roxb.) Nees., *Ochlandra beddomei* Gamble and few more species, *Oxytenanthera stocksii* Munro, *Pseudotenanthera bourdillonii* (Gamble) R.B.Majumdar, *Schizostachyum beddomei* (C.E.C. Fisch.) R.B. Majumdar, and *Yushania wightiana* (Nees) R.B.Majumdar. In addition, rattans, used as cane, belonging to genera of tribe Calameae of family Arecaceae are represented by a number of *Calamus* Auct. ex L. species.

Multipurpose species. *Falcataria moluccana* (Miq.) Barneby & J.W. Grimes, *Leucaena leucocephala* (Lam.) de Wit [syn. *Acacia leucocephala* (Lam.) Link], *Morus alba* L., and *vaka* or siris [*Acacia lebbeck* (L.) Willd.].

Wild relatives of cultivated species. Due to rich phytobiodiversity, the region has a large number of wild relatives of crop species, *Abelmoschus angulosus* Wall. ex Wight & Arn., *A. manihot* (L.) Medik. ssp. *tetraphyllus*, *Amorphophallus bonoccordensis* Yadav *et al.*, *A. commutatus* (Schott) Engl., *A. hohenakeri* (Schott.) Engl. & Gehrm, *A. mysorensis* E. Barnes & C.E.C. Fisch., *A. nicolsianus* Sivadasan, *A. smithsonianus* Sivadasan, *Artocarpus gomezianus* Wall. ex Trecul ssp. *zeylanicus* Jarrett, *A. hirsutus* Lamk., *Cajanus candollei* Wight & Arn., *C. lineatus* (Wight & Arn.) Maesen, *Carissa paucinervia* A.DC. (syn. *Carissa spinarum* L.), *Cinnamomum filipedicellatum* Kosterm., *C. heyneanum* Nees, *C. macrocarpum* Hook. f., *C. malabatrum* (Burm. f.) J.Presl, *C. riparium* Gamble, *C. travancoricum* Gamble., *C. wightii* Meissn., *Colocasia esculenta* (L.) Schott (taro), *Corchorus pseudo-olitorius* Islam and Zaid, *Crotalaria clarkei* Gamble, *C. digitata* Hook, *C. grahamiana* Wight & Arn., *Curcuma aromatica* Salisb., *C. aurantiaca* Van Zijp, *C. caesia* Roxb. (syn. *C. malabarica* Velay., Amalraj & Mural.), *C. coriacea* Mangaly & M.Sabu, *C. decipiens* Dalzell, *C. ecalcarata* Sivar. & Balach., *C. haritha* Mangaly & Sabu, *C. karnatakensis* Amalraj, Velay. & Mural., *C. kudagensis* Velay., V.S.Pillai & Amalraj, *C. nilamburensis* Velay., Mural., Amalraj, P.L.Gautam & S.Mandal, *C. neilgherrensis* Wight., *C. oligantha* Trimen (syn. *C. cannanorensis* R.Ansari *et al.*), *C. raktakanta* Mangaly & Sabu., *C. reclinata* Roxb., *C. thalakaveriensis* Velay., Amalraj & Mural., *C. vamana* M.Sabu & Mangaly, *Dioscorea hamiltonii* Hook. f., *D. hispida* Dennst (syn. *D. daemona* Roxb.), *D. intermedia* Thw., *D. oppositifolia* L., *D. pentaphylla* L. (syn. *D. jacquemontii* Hook. f.), *D. spicata* Roth, *D. tomentosa* Koenig ex Spreng., *D. wallichii* Hook. f., *D. wightii* Hook. f., *Dolichos uniflorus* Lam., *Ensete superbum* Roxb., *Eugenia singampattiana* Bedd., *Fragaria nilgerrensis* Schlecht. ex J.Gay, *Garcinia morella* (Gaertn.) Desr., *G. travancorica* Bedd., *G. wightii* T. Anders., *G. xanthochymus* Hook. f. ex T.Anderson, *Jasminum angustifolium* (L.) Willd., *J. flexile*, *J. malabaricum*, *J. mesnyi* Hance., *Linum mysorense*

B.Heyne ex Wall., *Luffa umbellata* (Klein) M.Roem. (dry areas bordering Tamil Nadu), spine gourd (*Momordica dioica* Roxb. ex Willd.) – harvested, *M. sahyadrica* Kattuk. & V.T.Antony, *Musa superba* Roxb., *Myristica dactyloides* Gaertn., *M. malabarica* Lamk., *Olea glandulifera* Wall. ex G. Don., *Oryza meyeriana* (Zoll. & Moritzi) Baill., *O. officinalis* Wall. ex Watt. [syn. *Oryza officinalis* Wall. ex Watt. ssp. *malampuzhaenensis* (Krish) Tateoka], *Piper argyrophyllum* Miq., *P. barberi* Gamble, *P. galeatum* C.DC., *P. hapnium* Buch.-Ham. ex Hook. f., *P. hookeri* Miq., *P. pykarahense* C.DC., *P. schmidtii* Hook. f., *P. silentvalleyensis* P.N. Ravindran, M.K. Nair & R. Ashokan, *P. trichostachyon* DC., and more (Parthasarathy *et al.,* 2006), *Pueraria tuberosa* DC. (Indian kudzu), *Sesamum laciniatum* Willd., *S. malabaricum* L., *S. mulayanum* Nair., *S. radiatum* Schumach., *Solanum anguivi* Lam. (syn. *S. indicum* L.), *S. erianthum* D. Don, *S. incanum* Ruiz & Pav., *S. nigrum* L., *S. pubescens* Willd. (syn. *S. torvum*), *S. viarum* Dunal, *Syzygium arnottianum* (Wight) Walp., *S. beddomei* (Duthie) Chithra, *S. malabaricum* (Bedd.) Gamble, *Trichosanthes anamalaiensis* Bedd., *T. cucumeriana* L., *T. nervifolia* L., *T. tricuspidata* Lour. [syn. *T. bracteata* (Lam.) Voigt], *T. villosula* Cogn., *T. wallichiana* (Ser.) Wight., *Vigna bournaea* Gamble, *V. pilosa* (Willd.) Benth., *V. vexillata* (L.) A.Rich. var. *wightii* Benth. ex Baker, *Vitis pedata* Wall., *V. repanda* W & A. (syn. *Cissus repanda* Vahl.), *Zingiber cernuum* Dalz., *Z. neesanum* (Grah.) Ramamoorthy (syn. *Z. macrostachyum* Dalz.), *Z. purpureum* Roscoe., *Z. roseum* (Roxb.) Roscoe, *Z. wightianum* Thwaites, and *Z. zerumbet* L.

Endemic species. Being a mega-center of species endemism, the region has a large number of economically important endemic plant species. Some of the representative endemic species are *Ammomum muricatum* Bedd., *Amorphophallus bonaccordensis*, *A. commutatus*, *A. smithsonianus, Andropogon longipes* Hack., *Arenga wightii* Griff., *Artocarpus hirsutus*, *Celmatis bourdillonii* Dunn., *Chlorophytum malabaricum* Dalz., *Cinnamomum keralense* Koster, *C. macrocarpum*, *C. malabatrum, C. travancoricum*, and many more, *Croton malabaricus* Bedd., *Curcuma cannanorensis* R. Ansari *et al.*, *C. cannanorensis* var. *lutea* R. Ansari, *C. kudagensis*, and more species, *Cymbopogon flexuosus* (Nees ex Steud.) Wts. var. *coimbatorensis* Gupta, *C. martini* (Roxb.) Wats var. *tofiaq* Gupta, *Diospyros nilagirica* Bedd., *D. pruriens* Delz., *Dipterocarpus indicus* Bedd., *Elaeocarpus munronii* (Wight) Mast., *E. recurvatus* Corner, *Eragrostis unioloides* var. *tremela, Eugenia argentea* Bedd., *E. discifera* Gamble, *Ficus dalhousiae* Miq., *F. beddomei* King., *Garcinia travancorica*, *G. wightii*, and more species, *Hopea glabra* Wt. & Arn., *H. parviflora* Bedd., *Ixora notoniana* Wall. ex D. Don, *Jasminum malabaricum* and more species, *Lilium neilgherrense, Mucuna pruriens* var. *hirsuta, Myristica malabarica* (*van-jayphal*), *Ochlandra travancorica, Piper barberi*, *P. galeatum*, *P. hapinum*, *P. schmidtii*, *P. trichostachyon*, *P. wighti* Miq., and more species, *Polyalthia fragrans* (Dalz.) Bedd., *Pterospermum reticulatum* Wt. & Arn., *Ranunculus subpinnatus* Wt. & Arn., *Rauvolfia hookeri* Srinivasan & Chitra, *Rhododendron arboreum* ssp. *nilagiricum* (Zenker) Tagg., *Syzygium bourdillonii* (Gamble) Rathakr & N.C. Nair, *S. chavaran*

(Bourd.) Gamble, *S. densiflorum* Wall. ex Wt. Arn., *S. gambleanum* Rathakr & Chitra, *S. malabaricum*, *S. mundagam* (Bourd.) Chitra, *S. palghatense* Gamble, *S. parameswaranii* Mohanan & Henry, *S. travancoricum* Gamble, *Trichosanthes anamalaienis*, *Vigna bourneae* Gamble, *V. vexillata* var. *wightii,* and *Zingiber neesanum.* Table 1 lists some economic plant species endemic to the region.

Threatened species. Natural factors and recent development activity has been eroding the biodiversity of the region. Some of the economically important plant species reported to be under threat are: *Albizia lathamii* Gamble*, A. thompsonii* Brandis, *Amomum microstephanum* Baker, *Amorphophallus dubius* Blume, *A. mysorensis, Artocarpus hirsutus* (Mathew *et al.*, 2006), *Buchanania barberi* Gamble, *Cajanus lineatus*, *Calamus brandisii* Becc., *Ceropegia barnesii* Bruce & Chatterjee, *C. beddomei* Hook.f., *Cinnamomum filipedicellatum*, *C. perrottetii* Meirs, *C. riparium*, *C. travancoricum*, *Coffea crassifolia* Gamble, *Cordia octandra* DC., *Crotalaria bourneae* Fyson, *C. clarkei*, *C. clavata* Wight. & Arn., *C. digitata*, *C. fysonii* Dunn. var. *fysonii, C. fysonii* Dunn. var. *glabra* Gamble, *C. grahamima*, *Curcuma decipiens*, *Dioscorea wightii*, *Diptercarpus bourdillonii* Brand., *Elaeocarpus recurvatus*, *E. venustus* Bedd., *Eugenia argentea*, *E. cotinifolia* Jacq. ssp. *codyensis* (Munro ex Wight) Ashton, *E. discifera*, *E. indica* (Wight) Chithra, *Garcinia trvancorica*, *G. wightii*, *Hopea erosa* (Bedd.) van Slooten, *Impatiens johnii* Barnes, *I. macrocarpa* Hook.f., *Ixora lawsoni* Gamble, *Jasminum wightii* C.B. Cl., *Kingiodendron pinnatum* (Roxb. ex DC.) Harms, *Luffa umbellata* (Kiein) Roem, *Madhuca bourdillonii* (Gamble) H.J. Lam., *M. insignis* (Radlk) H.J. Lam., *Oryza officinalis* ssp. *malampuzhaensis*, *Phyllanthus talbotii* Sedgw., *Piper barberi*, *P. hapnium*, *Rubus fockei* Gandhi, *Syzygium benthamiana* (Wight. ex Duthie) Gamble, *S. beddomei*, *S. bourdillonii*, *S. chavaran*, *S. gambleanum*, *S. occidentalis* (Bourd.) Gandhi, *S. palghatense*, *S. stocksii* (Duthie) Gamble, *S. travancoricum*, *Trichosanthes anamalaiensis* Bedd., *Vanda wightii* Rchb.f., *Vanilla wightiana* Lendil. ex Hook.f., and *Zingiber cernuum.* Representative economic plant species under threat in the region are listed in Table 2.

Associated culture and tribes

Archaeological studies have identified many Mesolithic, Neolithic, and Megalithic sites in the region. The studies suggest a possible relationship of the region with the Indus Valley civilization during the late Bronze Age and early Iron Age. The foreign cultural contacts further assisted the cultural formation. Therefore, the culture of the region traces its roots to 3rd century CE and earlier. It is a synthesis of Aryan and Dravidian cultures, developed over centuries under influences both from within India and abroad. Agriculture was the dominant activity of the region, is reflected by the fact that the region had been a prominent spice exporter from 3000 BCE to 3rd century, which would not have been possible without identification of the economic potential of plant species, their domestication, and development of agricultural practices for qualitative and quantitative production in large quantities for trade/export. The fame of the region as the land of spices

Table 1. Representative economic plant species endemic to the Malabar region, India.

Species	Family	Habit	Distribution	Use
Amorphophallus bonaccordensis	Araceae	Herb	Agasthyamalai hills	Genetic resource
Amorphophallus commutatus	Araceae	Herb	Malabar region	Genetic resource
Amorphophallus smithsonianus	Araceae	Herb	Agasthyamalai hills	Genetic resource
Arenga wightii	Arecaceae	Tree	Malabar region	Fermented drink
Artocarpus hirsutus	Moraceae	Tall large tree	Malabar region	Fruit, wood (threatened)
Arundinaria densiflora	Poaceae	Gregarious bamboo	Anamudi hills	Mulipurpose
Chlorophytum malabaricum	Agavaceae	Herb	Southern Western Ghats	Medicinal
Cinnamomum macrocarpum	Lauraceae	Tree	Malabar region	Genetic resource
Cinnamomum malabatrum	Lauraceae	Tree	Southern Western Ghats	Medicinal
Cinnamomum travancoricum	Lauraceae	Small tree (10–15 m tall)	Southern Kerala	Genetic resource
Croton malabaricus	Euphorbiaceae	Tree	Southern Western Ghats	Medicinal
Curcuma cannanorensis	Zingiberaceae	Herb	Kannur	Genetic resource
Curcuma malabarica	Zingiberaceae	Herb	Southern Western Ghats	Medicinal
Cymbopogon martini var. *tofiaq*	Poaceae	Grass	Southern Western Ghats	Lemon grass
Diospyros nilagirica	Ebenaceae	Tree	Southern Western Ghats	Fruit
Diospyros pruriens	Ebenaceae	Evergreen tree	Southern Western Ghats	Good timber, fruit
Dipterocarpus indicus	Dipterocarpaceae	Evergreen tree	Southern Western Ghats	Timber, medicinal
Elaeocarpus munronii	Elaeocarpaceae	Tree	Southern Western Ghats	Edible fruits,wood

continued

Table 1. *continued*

Species	Family	Habit	Distribution	Use
Eragrostis unioloides var. *tremela*	Poaceae	Fodder grass	Travancore	Fodder grass
Garcinia travancorica	Clusiaceae	Tree	Southern Western Ghats	Condiment
Hopea glabra	Dipterocarpaceae	Tree	Southern Western Ghats	Medicinal
Hopea parviflora	Dipterocarpaceae	Evergreen tree	Southern Western Ghats	Medicinal
Ilex malabarica	Aquifoliaceae	Large tree	Southern Western Ghats	Wood for boxes
Ixora notoniana	Rubiaceae	Small tree	Southern Western Ghats	Ornamental
Jasminum malabaricum	Oleaceae	Straggling shrub	Southern Western Ghats	Ornamental, medicinal
Lilium neilgherrense	Liliaceae	Ornamental plant	Nilgiris to Travancore	Ornamental
Mucuna pruriens var. *hirsuta*	Fabaceae	Climbing shrub	Southern Western Ghats	Genetic resource, medicinal
Myristica malabarica	Myristiaceae	Tall tree	Southern Western Ghats	Medicinal, genetic resource
Piper schmidtii	Piperaceae	Large climbing shrub	Southern Western Ghats	Genetic resource
Polyalthia fragrans	Annonaceae	Tree	Malabar region	Flowers fragrant, wood
Pterospermum reticulatum	Sterculiaceae	Tree	Southern Western Ghats	Wood, boat making
Rhododendron arboreum ssp. *nilagiricum*	Ericaceae	Tree	Nilgiri and Idduki hills	Ornamental
Sorghum stapfii	Poaceae	Tall herb	Kalakad ranges	Forage, genetic resource
Vateria indica	Dipterocarpaceae	Tree	Southern Western Ghats	Gum resin, white dammar
Vigna vexillata var. *wightii*	Fabaceae	Herb	Southern Western Ghats	Genetic resource
Zingiber neesanum	Zingiberaceae	Herb	Southern Western Ghats	Genetic resource

Table 2. Representative economic plant species under threat in the Malabar region, India.

Species	Family	Habit	Threat level[1]	Use
Albizia thompsonii[2]	Fabaceae	Tree	R	Wood
Cajanus lineatus	Fabaceae	Shrub	DD	Genetic resource for pigeonpea
Calamus brandisii	Arecaceae	Scandent shrub	R	Construction
Cinnamomum travancoricum	Lauraceae	Tree	R	Genetic resource
Coffea crassifolia	Rubiaceae	Stiff shrub	R	Genetic resource of coffee
Crotalaria clarkei[2]	Fabaceae	Herb	R	Genetic resource
Crotalaria digitata[2]	Fabaceae	Shrub	R	Genetic resource
Crotalaria grahamima[2]	Fabaceae	Under shrub	R	Genetic resource
Dioscorea wightii	Dioscoreaceae	Climbing herb	R	Tubers rich in saponin
Elaeocarpus recurvatus[2]	Elaeocarpaceae	Tree	VU	Endemic, source of wood
Eugenia argentea[2]	Myrtaceae	Shrub	EN/P.EX	Endemic, spice, ornamental
Garcinia wightii[2]	Clusiaceae	Tree	EN	Endemic, fruit
Jasminum wightii[2]	Oleaceae	Wiry climber	R	Endemic, ornamental
Madhuca bourdillonii[2]	Sapotaceae	Tree	EN	Endemic, wood
Oryza officinalis ssp. *malampuzhaensis*	Poaceae	Tall herb	DD	Genetic resource, forage grass
Piper barberi[2]	Piperaceae	Scandent undershrub	CR	Endemic, genetic resource
Piper hapnium	Piperaceae	Climbing undershrub	R	Endemic, genetic resource
Syzygium bourdillonii[2]	Myrtaceae	Small tree	EN	Endemic, silvery leaves, spice
Syzygium travancoricum[2]	Myrtaceae	Tree	CR	Ornamental
Zingiber cernuum	Zingiberaceae	Herb	DD	Genetic resource

1. CR = Critically endangered; EN = Endangered; DD = Data deficient; R = Rare; VU = Vulnerable; P.EX = Possibly extinct.
2. Listed by the Ministry of Environment and Forests, Government of India.

attracted ancient Babylonians, Assyrians, and Egyptians to the region in the 3rd and 2nd millennia BCE. The Arabs and Phoenicians were also successful in establishing their prominence. The first powerful state rule in the region was established with the

Chera Dynasty. During the Chera period the region remained an international spice trading center. In the last centuries BCE, the region became famous among the Greeks and Romans for its spices, especially black pepper. The *Cheras* had trading links with China, West Asia, Egypt, Greece, and the Roman Empire. In the foreign-trade circles, the region was identified by the name *Male* or *Malabar*. Though the name is thought to be derived from the Malayalam word *Mala* (hill) and *puram* (region), derived or westernized into *bar*. Later, in the 15th century, the lucrative spice trade attracted Portuguese traders to the region, which eventually paved the way for European colonization. Recognizing the importance of the knowledge the local communities had about the value of plants documented in Malayalam, a comprehensive treatise dealing with properties of the flora of the region was translated into Portuguese and Latin over a period of 30 years and published from Amsterdam as the '*Hortus Malabaricus*' (1678–1693).

Most tribals of the region live in the forests and mountains. Kerala only has around 32 named tribes. Most primitive tribes are still food gatherers and honey and firewood collectors from the forest (*Malakkuravans*, *Malayans, Mannan*), but are now involved in farming. The main tribes associated with the region are *Adiyan* (agricultural workers), *Aranadan* (nomadic), *Hill Pulaya*, *Irulan*, *Kanikar*, *Kuruman*, *Malai Pandaram*, *Paniyan*, *Ulladar*, *Jenu Kuruba*, *Kani* (herbal medicine), *Koraga*, *Cholanaickans*, *Kadar*, *Kurumbas*, and *Kattunaickans*. The last five tribes represent 5% of the total tribal population, of which *Cholanaickans* are the most primitive, found only in the Malappuram district and are under threat. On the Malabar Coast, five ethnic communities established from time immemorial are the *Nairs* or *Naimars*, the *Kurgas* or *Kudagas*, the *Tulus*, the *Konkanis* and the *Kanaras*. These people have preserved their language and way of life. The region is predominantly Hindu, but sizable populations of Muslims known as *Mappilas*, as well as of Syrian Christians also live.

Technology and products

The excess water caused by excessive rains and regular action of sea waves and shore currents in the coastal areas, including areas below sea level have been harmoniously managed by the local populations with ingenuity, creating a network of backwaters. The backwaters are a chain of brackish lagoons connected by natural and artificial canals. They represent a unique ecosystem, where freshwater from the rivers meets the seawater from the Arabian Sea. In certain areas, such as the Vembanad Kayal, a barrage has been built (Kumarakom) to restrict the entry of salt water from the sea to deep inside mainland, keeping the freshwater intact. Such freshwater is extensively used for irrigation of crops.

Archaeological studies have identified many Mesolithic, Neolithic, and Megalithic sites in the region. The studies suggest a possible relationship of the region with the Indus Valley civilization during the late Bronze Age and early Iron Age.

The backwater channels have been used for transport, and a large amount of local trade in the region is carried by inland navigation. Fishing, fish curing, and wet agriculture are the other important activities that have been performed by the local people in the backwaters from centuries. Encouraged with this unique traditional agroecosystem, agricultural efforts have been strengthened in recent times with the reclamation of more lands for rice cultivation, particularly in the Kuttanad area. Further, reconciling with such a landscape, the local communities also developed boat making and the coir industry and other traditional crafts in the backwaters for livelihood support.

The local people have great respect for Mother Earth and plants, which has facilitated the conservation of rich biodiversity in sacred groves called *Kavu* or *Serpa Kavu*. In these sacred groves, sacred plants and serpents are worshipped as per Hindu rituals. During ancient times, households usually set aside the southwest corner of their land for sacred groves, which were dedicated to plants and snakes. However, at present, most sacred groves are on the decline along with their precious biodiversity. Under the same ethos, the farmlands were identified with the Mother Goddess, and just as women need rest after delivery, the farmlands were left fallow to give them rest after the harvest, with all tilling prohibited during this period (closed season). Being the part of west coast of the Indian peninsula, where local communities had orientation for maritime commerce, the Malabar Coast also evolved a number of historic port cities over time in continuation of the Konkan. Several ports such as the Muziris, Beypore, and Thundi (near Kadalundi) were known from ancient times for the Indian trade through ocean, while others such as Kozhikode (Calicut), Cochin, and Kannur (Cannanore) from the medieval period serving as trade centers. Many are still functional. These port cities were very cosmopolitan and have played an important role in cultural diversification, by hosting some of the first groups of Christians (known as Syrian Christians/ Malabar Nasrani), Jews (known as Cochin Jews), and Muslims (known as *Mappilas*). Also, they hosted the introduction and adaptation of exotic crop species such as coffee (from Yemen, by the Arabs), tea (from China), cassava, pineapple, papaya, *sapota*, tobacco, chili, potatoes and many others (by the Portuguese), cocoa, rubber (from Brazil) and even tree spices such as nutmeg, clove, and allspice (*Pimenta dioica*) during the 18th century (by the British and Dutch) from Moluccas, enriching the agrobiodiversity of the region and the country, in addition to the crops from northern India and locally domesticated during ancient period in the region, such as black pepper, cinnamon, cardamom, etc. Consequently, the Malabar region came to be known throughout the world as the land of spices with a reputation for quality black pepper, cardamom, ginger, cinnamon, nutmeg, mace, and other spices. It also led to the dispersal of Indian crops such as pepper and jackfruit taken by the Portuguese to all tropical regions of the world, enriching global agrobiodiversity.

Agriculture is very old in the region and several tribal communities still practice primitive slash-and-burn cultivation (Kumari cultivation) in the hilly areas of Kerala (Suresh, 2010). *Jhum*, slash

and burn cultivation called '*punamvalal*' or *punam* is now extinct/banned by the forest department. While the other oldest and the most enduring form of cultivation in smallholdings adjacent to human settlements, referred as 'home gardens' has become more prevalent with rich indigenous knowledge about crop characteristics. Otherwise, the region has mainly evolved and practiced wet and tropical agriculture on farm and in home gardens. Rice, being the staple food, was traditionally cultivated both on lowland (*Ubayum*) and uplands (*Plaealil*). Additionally, the local communities had developed cropping systems both for rice and other crops suited to the topography, availability of water, and edaphic conditions. According to Buchanan's (1807) descriptions, during the 18th and 19th centuries, Malabar farmers preferred transplanted paddy in *Ubayum* lands. On *Plaealil* lands sprouted seeds were directly sown. Farmers grew several genotypes such as *Navara*, a short-duration medicinal variety maturing in 90 days. Most other rice cultigens, such as *Watun*, *Calli*, *Caruma*, *Ari modun*, *Cheru Modan,* and *Ari Caruma* matured within four months. The *Ubayum* land may have perpetual standing water hence it was used only for one cropping season. In hilly tracts or *Parumbu,* cereals such as *shamay* (*Panicum miliare*), pyro-legume (grain legume), turmeric, and ginger were grown. Upland or hill-paddy (*Modun*) was cultivated on land previously plowed at least three to four times. Such a crop was sown in July/ August. Sesame followed immediately after harvest of rice. Rice cultivars suited as second crops in the region were *Maliga* or *Shiriga*, *Sambau*, *Shittany*, *Bally shittany,* and *Noman* (Buchanan, 1807). The second crop of rice was always transplanted. The crop rotations followed in the region depended on the fertility of soils. On hilly or poor soils, *shamay–slindu* (black gram) was adopted in a three-year rotation, while in a two-year rotation, sesame–*shamay* or sesame–pulses were common crops.

Most tribals of the region live in the forests and mountains. Kerala only has around 32 named tribes. Most primitive tribes are still food gatherers and honey and firewood collectors from the forest* (Malakkuravans, Malayans, Mannan), *but are now involved in farming.

***The local people have great respect for Mother Earth and plants, which has facilitated the conservation of rich biodiversity in sacred groves called* Kavu *or* Serpa Kavu.**

Responding to the undulating landscape, high rainfall and hot and humid tropical conditions, plantation crops were more frequent in the region. For maximum exploitation of land, most plantations followed multistoried cropping. The coconut and betel nut plantations allowed understory cropping. Commonly suited understory crops were *shamay* (*Panicum miliare*), sesame, and legumes such as *Vigna* species. Spices such as pepper (*Piper nigrum*) thrived well on lateritic soils. In the Travancore region, *Parumba* (hilly) lands were used for raising fruit trees, such as coconut, jackfruit, and

mango, and also to produce hill rice, *shamay*, and sesame (Buchanan, 1807).

Evolution of innovative farming has continued in the region (Fig. 3). In the Kuttanad area of the Alappuzha district of South Kerala, the sea ingress increases the soil salinity, as the area is below the sea level. However, the local communities have interacted harmoniously with this set of landscape/physical conditions, selecting and cultivating salinity-tolerant varieties, below sea level (about 4 to 10 feet). As four major rivers, namely Pampa, Meenachil, Achankovil, and Manimala also flow into the region, this area is intensively cultivated and is known as the rice bowl of Kerala. Vast stretches of verdant paddy fields interlaced with enchanting backwaters create some unforgettable sights. Cultivation and harvesting is done in this area two or even three times in a year. The practice of rice cultivation in waterlogged areas of southern coastal Kerala (Alappuzha) is called '*pokkali*'. It is a unique cultivation system of salinity-tolerant rice varieties, cultivated in an organic way in the waterlogged coastal regions (Fig. 5a). It has been further strengthened with integrated rice–shrimp/prawn farming. One rice crop followed by shrimp/prawn capture provides a substantial subsidiary income to the farmer (Jayan and Sathyanathan, 2010). This system is also widely practiced in Thrissur and Ernakulam districts. In the Kannur district of North Kerala, a similar system called '*kaipad*' is practiced with the rich biodiversity of flora and fauna, organically rich soil, mangroves, and migratory birds (Fig. 5b). It differs from *pokkali* in the way it is carried out, which is purely natural way relying on the monsoon and the sea tides. Besides, it has its own salinity-tolerant landraces of rice and high-yielding rice varieties (Vanaja, 2013). *Kaipad* is also practiced in Kasaragod and Kozhikode. These two systems are testimony to the local community's ingenuity in harnessing the natural events for farming in an ecofriendly manner.

The variation in resource endowments, topography, soil, abiotic factors, and season, and natural and artificial selection pressures operating in various areas, under different agroclimatic conditions, over long periods of time have resulted in the evolution of a large number of farmers'

Figure 5. Rice cultivation: (a) *Pokkali* system in South Kerala (Source: The Hindu, KK Mustafah); and (b) *Kaipad* system in North Kerala (Source: The Hindu, October 2009).

varieties/landraces suited to each area with specific traits like resistance to biotic and abiotic stresses, ability to survive extreme climatic and agro-edaphic situations, and with quality attributes such as medicinal value, aroma, and grain characteristics suited to special uses, generating a reservoir of genes that are used and can be used in development of superior varieties. Leena Kumari (2012) presumed that around 2000 genetically diverse traditional rice varieties are grown in the Kerala area of the region. Latha *et al.* (2013) listed landraces of rice from the Kerala area and have argued that the humid tropical coastal and midlands of Kerala in the Southern Western Ghats can be considered as one of the secondary centers of diversity for rice with 7 wild relatives and 623 named landraces. The range of characters identified in these landraces/varieties are: crop duration, plant height, tillering, pigmentation of various plant parts, panicle characters, and grain characteristics and straw production. There are photo-insensitive and photosensitive varieties, maturing between 60 and 260 days. Grain characterstics offer tremendous variation for: grain color, shape, size, aroma, puffing, popping, flattening, cooking and eating qualities. Grain color itself varies from straw to gold to brown tinges, to complete brown and black. The grain size varies from round to short bold, to long bold to long slender. Local farmers prefer long bold red-kernelled grains.

Selection among landraces/varieties has resulted in the identification of genotypes with desired traits such as early maturity (115 days or less) in *Hraswa*, *Annapoornna*, *Triveni*, *Rohini*, *Jyothi*, *Kairali*, etc.; medium maturity (115 to 130 days) in *Aswathi*, *Athira*, *Aiswarya*, *Ramya*, *Kanakam*, etc.; and long maturity (130 days) in *Lakshmi*, *Dhanya*, *Nila*, *Rasmi*, etc.; with genes conferring resistance to abiotic and biotic stresses, such as *Pokkali* and *Kaipad* varieties (*Orissa*, *Cheruchitteni*, *Orpandy*, *Odiyan*, *Kuthiru*, *Orkayama*, *Mahsuri*, *Mundon*, *Kundorkutty*, and *Punchakayama* from North Kerala); with salinity tolerance Ptb21 from Thrissur and *Veluthachira* with gall midge resistance; Ptb 33, a traditional cultivar with gene bph3 conferring a high level of resistance, from Pattambi against the brown plant hopper populations found in many Asian countries (Seshu and Kaufmann, 1980) and scented varieties such as *Jeerakasala* and *Gandhakasala.* This genetic diversity of landraces/traditional varieties has been used in the development of new varieties, for example the variety '*Sagara*' is a pure line selection from the traditional variety *Orumundakan,* released for cultivation in the saline areas of Karthikappally taluk of Kerala. Pattambri varieties have been developed using local varieties such as *Aryan*, *Pannaryan*, *Vellari*, *Tharalakannan* (frog-eyed), *Thekkancheera*, *Thekkanchitteni*, *Vadakkanchitteni*, *Thekkan*, *Cheriyaryan*, *Kodiyan*, *Kattamodan*, etc. (Tiwari, 2006).

The region is also known for varieties with medicinal properties, such as *Njavara*, *Chennellu*, *Kunjinellu*, *Erumakkari*, *Karuthachembavu*, and *Kavunginpoothala* (Leena Kumary, 2004). *Njavara*, is known as '*Shashtika*' ("60") in Sanskrit, due to its extra-short-duration (60–70 days). Two types of *Njavara* have been recorded, the white-glumed and the black-glumed.

The practice of rice cultivation in waterlogged areas of southern coastal Kerala (Alappuzha) is called* 'pokkali'. *It is a unique cultivation system of salinity-tolerant rice varieties, cultivated in an organic way in the waterlogged coastal regions.

Njavara rice is used in Ayurvedic treatment for paralytic conditions and muscle wasting. It increases the growth of muscles and stimulates the nerve endings. *Chennellu* and *Kunjinellu* are varieties indigenous to North Kerala. One type of *Chennellu* has bright red grains, grown as an upland variety in parts of Kannur district and is used in the treatment of diarrhea and vomiting. *Erumakkari* and *Karuthachembavu* are the traditional rice varieties indigenous to South Kerala. *Karuthachambavu* has black grains. *Erumakkari* is used in the treatment of cough. *Annoori*, a wild species of rice, is used by the *Kani* tribes for treatment of smallpox. *Kavunginpoothala* is indigenous to the Palakkad district, and is given to diabetic patients to reduce discomfort (Leena Kumary, 2004).

The MS Swaminathan Research Foundation (MSSRF) has identified the Wayanad district in the northeast of Kerala as an important agrobiodiversity hotspot for rice, pepper, and tuber crops. It has high genetic diversity in rice with about 600 landraces. The MSSRF has identified the following rice varieties for conservation: *Anakkodan, Gandhakasala, Jeeragasala, Kundipullu, Mullanchanna* among scented varieties; *Kotta nellu, Kuttadon, Oormundakan* among flood-tolerant varieties; *Chettiviruppu, Chovvaryan* among salt-tolerant varieties; *Thekkenthouvan, Vella thouvan, Veliyan* among drought-tolerant varieties; and *Chennellu, Njavara, Vattan* among medicinal rice varieties.

The production of crops adjacent to human settlements in homestead farming systems or home gardens is one of the oldest forms of cultivation practiced from ancient times, because of tropical conditions and dominance of horticultural crops. It has shown renewed interest responding to shrinking landholdings and to help farmers meet their livelihood requirement in a subsistence manner. Home garden systems have evolved rationally, and the components of the system are based on the physical climate and the requirements. Coconut-based home gardens are most common (Fig. 2), intercropped with a range of crops, cultivated in a multistoried cropping system, similar to tropical rainforests to facilitate the maximum and effective land use without restricting the interception of light energy. Under these systems, the structural diversity created with four layers of canopy in multiple-cropping of crops of various heights is an intentional strategy to achieve higher efficiency of resource use, while the functional diversity of the components helps in meeting the diverse demands from food to fodder to fuel to fertilizers (organic) to medicinal requirements, etc. The home gardens may often be combined with livestock rearing, where the components interact in a synergistic manner. This may help improve the nutritional security of household members and augment farm income. The crop residues and fodder

provide animal feed and manure, while livestock litter provides a renewable source of organic matter and plant nutrients. Thereby, these systems reduce the outside dependence of farmers for resources, and help conserve soil fertility through organic recycling.

As the home gardens of the region are self-contained and are need-oriented systems, they are predominantly organic and depend on biological control for pests and diseases with the use of botanicals such as tobacco decoction, neem extracts, etc. The use of multiple species in these systems exhibits considerable bio-resource diversity, basically designed to meet the food, fodder, fuel, organic mulch, timber, and medicinal requirements of the households and to generate cash (Fig. 4). Besides, it helps in the conservation and sustainable use of resources. Most species grown under these systems have multiple uses, starting from food to food-flavoring to home remedies for various ailments. This has made these systems environment-friendly, sustainable, and efficient. The integration of livestock has also been designed with cropping strategy focusing on meeting the fodder/ feed requirement, either through cultivation of fodder crops like grasses, or crops producing nutrient residue, as a basal crop. These systems basically evolved to support the subsistence farming, and are being further strengthened with the introduction of cash crops such as rubber, coffee, and vanilla or income-generating components (Fig. 4) such as apiculture, sericulture, or mushroom cultivation in addition to livestock, which includes cows, buffaloes, goats, pigs, and poultry. The southern Karnataka portion is characterized with areca gardens intercropped with coffee, banana, vanilla, pepper, cocoa, etc.

The physical and biological diversity of the home gardens has generated significant genetic diversity in a range of field crops, such as pulses, oilseeds, and horticultural crops. In pigeonpea, a high-performing ratoonable landrace, PR5193, selected from the fields of ethnic communities of Attapadi, has been released directly as a variety for use in livestock systems. In sesame, the variety Kayamkulam-1 has been selected from a local landrace from Onathukara local. In addition, the wild relatives available in the region, for example in sesame, i.e., *Sesamum laciniatum* and *S. mulayanum*, have contributed resistance to phyllody and powdery mildew to the cultivated crop species *Sesamum indicum* (Mehetre *et al*., 1993).

In horticultural crops, cultivation under the diverse agroecosystem of homestead gardens has generated rich genetic diversity in many crops. Among vegetables, in *Cucurbita moschata*, the variety *Ambili* has been developed from Kerala local. In okra, cultivated *Abelmoschus caillei* introduced from West Africa has adapted well to backyard cultivation and is naturalized with significant diversity. Some collections of *A. caillei* segregated into cultivated *A. caillei* types, and also types resembling *A. manihot* var. *tetraphyllus* (Velayudhan *et al.,* 2007). The wild *Abelmoschus angulosus* is an additional genetic resource for use in crop improvement. The genetic diversity in *Solanum* and cucurbitaceous vegetables and *Vigna* species is also represented by a

number of indigenous and endemic wild species.

Among fruits, in banana, the region offers great diversity in fruit traits and quality. The clonal variation itself ranges from red, green to yellow. The region is known for different cultivars, from red-skinned *Kappa*, large yellow-skinned *Nendraka* to small yellow-skinned *Kadali*, *Rasakadali*, *Poovan*, *Matti*, *Palayamkodan*, and green-skinned *Padatti* and *Morris*. The region is also known for traditional varieties of mango such as *Mundappa*, *Olour*, and *Pairi*. In jackfruit, *Varikka*, *Koozha*, and *Navarikka* are three classified types, based on fruit quality. *Varikka,* with slightly hard inner flesh when ripe, is preferred by people. Some common jackfruit varieties are *Thamara Chakka*, *Moovandan*, *Padavalam Varikka*, *Vakathanam Varikka*, *Muttom Varikka*, *Then Varikka*, *Athimadhuram Koozha*, *Rudrakshi*, *Ceylon Varikka*, and *Thenga Chakka*. The Coorg (Kodagu) mandarin (*Citrus reticulata*) from the Karnataka region is a popular cultivar. In *Garcinia, Syzygium*, and *Diospyros*, in addition to genetic diversity of cultivated species, several indigenous and/or endemic species present diversity for various fruit traits. The fruit extract of *Garcinia indica* has become a popular drink from the region called *kokum*.

The region is the primary center of origin and diversity for cardamom and black pepper with local cultivars presenting maximum variability. Cardamom (*Elettaria cardamomum*) has three distinct types: *Malabar*, *Mysore*, and *Vazhukka* types. A number of cultivars have been developed, such as Mudigere-1 by clonal selection from Malabar type, PV1 from Walayar collection, ICR11 from Chakkupalam collection, ICR13 from Malabar type, and ICR14 from the Vadagaraparai area. In pepper (*Piper nigrum*), cultivars and a number of wild indigenous/endemic species present significant genetic variability. Several cultivars have been developed through clonal selection from local types, such as Panniyur 4 from *Kuthiravally*, Sreetara from *Karimunda*, Panchami from *Aimiriyam*, Pournami from *Ottaplackal*, PLD 2 from *Kottanadan* and Panniyur 6 from *Karimunda.* In ginger, significant variability is presented with a large number of wild *Zingiber* indigenous/endemic species, and products like *Kuruppampady* and IISR Varada have been derived through clonal selection from Kerala local. In turmeric (*Curcuma longa*), significant variability exists for yield, quality attributes, and dry recovery. There are well-known cultivars such as *Alleppey*, which is considered high-yielding with quality rhizome. Suguna Sobha is a clonal selection from a local germplasm (Ravindran *et al.,* 2005). Velayudhan *et al*. (2012) have considered the region as one of the hotspots for the genus *Curcuma* with about eight tuber-bearing, one stolon-bearing, and 16 non-tuberous species. *Myristica fragrans*, the nutmeg introduced from Indonesia has naturalized to the region, and presents variability due to its dioecious nature and sexual propagation, for characters such as fruit size, shape, mace, and seed volume (Krishnamoorthy *et al.*, 1997). Additionally, a large number of *Cinnamomum* species are endemic and therefore the Malabar region is considered the center of origin or one of the centers of diversity. Cinnamon leaf oil naturally contains eugenol and the bark

oil cinnamaldehyde, giving cinnamon its flavor and odor. Varieties like Navasree, a seedlings selection from Sri Lankan collections, and Nithyasree from the Indian collection have been produced. Malabar tamarind, *Garcinia gummi-gutta* also has considerable variability.

The region is rich in diversity for several minor tuber crops such as arrowroot or *koova* (*Maranta arundinacea*), Chinese potato (*Solenostemon rotundifolius*), Queensland arrowroot (*Canna edulis*), winged bean (*Psophocarpus tetragonolobus*), and yam bean (*Pachyrrhizus erosus*), which are used as alternative food crops in the Kerala area. In these species, products Sree Dhara and Nidhi in Chinese potato were developed through clonal selection, and CP58 and Rajendra Mishrikand-1 in yam bean with resistance to insect pests and diseases, through seedling selection in local collection (Edison *et al.*, 2005). In yams, the indigenous and endemic *Dioscorea* species presents important genetic diversity. The region is also known for variability and quality in commercial crops such as coconut, coffee, cashewnut, tapioca, and rubber. Consequent to the association of such unique diversity with the region, several agricultural products are protected under India's Geographical Indications of Goods Act, such as the *Monsooned Malabar* coffee derived from exposure to the monsoon winds of the Malabar coast, *Malabar pepper*, *Vazhakulam Pineapple*, *Alleppey green cardamom*, *Palakkadan Matta rice*, *Pokkali rice*, *Wayaanad gandhakasala rice*, and *Wayaanad jeerakasala rice* (Elsy, 2012).

Apart from the wealth of indigenous knowledge regarding natural resource management and sustainable cultivation practices that evolved over time, the region is also known for knowledge about the medicinal properties of plants. More than 1000 plants with medicinal value have been reported from the mountains of the Southern Western Ghats. The availability of these medicinal plants and their use in the traditional medicine system of Ayurveda in unique therapies has made the region a famous destination for medical tourism. The '*Hortus Malabaricus*' (The Garden of Malabar) (1678–1693) documents the medicinal properties of the plant wealth from the region in Latin (Manilal, 2003). As per the demand of environmental and soil conditions, the farmers of the region consistently used small hand-held implements such as *padana caicota* or *haray* of different shapes. A pick-axe known as *Malagi* was used to dig channels around cropping areas.

The region is also known for evolving and conserving animal breeds (genetic resources) with reputable high prolificacy, milk yield, excellent growth rate, and adaptability to the hot humid conditions. Cattle breeds of the region are small in size. The *Vechur* cow, the pride of Kerala, derives its name from the village Vechur, a small place by the side of the Vembanadu Lake near Vaikom in Kottayam district. Once thought extinct due to extensive crossbreeding, it has been saved by the recent efforts on multiplication and its recognition as a distinct smallest breed of the world. The other popular breed is *Kasargode Dwarf* cattle from the Kasaragod district. In buffaloes, the

Kuttanad buffaloes are the most extensively used breed for plowing the marshy and deep paddy fields of Kuttanad. In the case of goats, the production had mainly centered on the native *Malabari*/*Tellichery* breed, which evolved by crossing *Jamnapari*, *Surti*, and *Arab* goats with local goats (Kaura, 1952). The other breed known as *Attapadi Black* is hardy in nature, disease-resistant with an excellent growth rate. *Angamali* pigs are native pigs of Kerala, smaller in size, pot-bellied, hairy and black in color with long face and short ears. Two morphologically distinct groups exist, one with a short snout and dished back, and the other, hairy with a long snout and non-dished back. Similarly, in poultry, the native chicken breeds developed and conserved by the local communities offer variability of white, black, red, gold-brown, and mixed color with good brooders and mothers, while Kuttanad ducks are represented by *Chara* and *Chamballi* breeds.

The region is abundantly rich in marine, brackish water (including *pokkali* and prawn filtration fields and private shrimp farms) and freshwater aquatic biodiversity, occupying the foremost positions. These water bodies are inhabited by a wide variety of aquatic fauna and flora. These resources have brought people belonging to different ethnic groups in contact with fishing, and therefore fishery is still a largely people-centered activity. Cooperative organization for fishermen was undertaken in the region as early as 1917. Under marine waters, the major resources are of shrimps, cuttle fish, sardines, mackerels, anchovies, soles, sharks, rays, etc. In brackish waters, fisheries resources consists of 75 species

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of which 57 species are of fish, six of shrimp, one of prawn, five of crabs, and six of bivalves. Twenty-eight species identified are commercially important. Some species of sardine and anchovies, mullets, catfishes, perches, pearl spot, prawns, oysters, mussels, crabs, and clams are the most common. The freshwaters are known for richness in fish species with around 210 primary fishes (carps, cichlids, etc.), of which 53 species are endemic. The majority of these fishes also have ornamental value. The cultivable food fishes native to Kerala include Thooli (*Labeo dussumieri*), Kooral (*Gonoproktopus curmuca*), Manjakoori (*Horabagrus brachysoma*), Kuyil (*Tor khudree*), Katti (*Tor mussallah*), Pulivaka (*Channa micropeltes*), Musi (*Clarius batrachus*), Manalvaka (*Channa leucopunctatus*), Brahmanakandi (*Lepidopygopsis typus*), Wynad Musi (*Silurius wynadensis*), etc. Several endemic fishes such as *Mastacembalus armatus*, *Horabagrus brachysoma*, *Mesonoemacheilus guntheri*, *M. monilis*, *Tetradon travancoricus*, *Puntius enisonii*, *P. aurilius*, *P. jerdoni*, *Barilius bakeri*, *Tor khudree*, *T. mussallah*, etc. have high ornamental value. Recently, a large number of new fish species have been reported, such as *Garra periyarensis, G. surendranathani*, *Mesonemacheilus menoni*, *M. periyarensis*, *Travancoria elongata*, *Salarius reticulates*, and *Puntius*

muvattupuzhaensis. In addition, from cold water commercially important fishes include *Salmo* sp., *Tor* sp., *Schizothorax* sp., *Acrossochelius* sp., *Puntius* sp., etc. However, these resources are on the decline, and need attention for conservation to facilitate sustainable use. There is much scope for modernization and diversification of the existing facilities. The rare and ornamental fishes offer new opportunities, because of the high demand in the domestic and foreign markets (Harikumar and Rajendran, 2007).

Future perspective

The excessive leaching due to high rainfall along the steep landscape is leading to the depletion of top soil and plant nutrients. Similarly, the region is losing the tree cover which binds the steep slopes resulting in frequent landslides. These and development factors are causing a decline of biodiversity in general, and that of local diversity of important fruits like jackfruit, mango, etc., and those of multipurpose tree species such as *anjili* (*Artocarpus hirsutus*), used for timber, *punna* (*Calophyllum inophyllum*), source of biofuel, etc., in particular, demanding conservation.

Traditional homestead gardens, which are a major source of household requirements and spices/cash crops for income, need research attention for the appropriate mix of fruit trees and food crops which are ecologically and economically more sustainable and can also be used on slopes and along with paddy in the valleys to restrict soil erosion and keep them dynamic. These systems need to be made agri-business-based and strengthened with diversification and infrastructure support for improved productivity and restricting wastage.

The freshwaters are known for richness in fish species with around 210 primary fishes (carps, cichlids, etc.), of which 53 species are endemic.

The region was known for organic food; however, there is perceptible decrease in the production of organic manure and farming, increasing dependence on costly and ecologically damaging chemical fertilizers. Therefore, traditional practices need to be reinvented in conjunction with modern technologies.

Waterlogging and sea intrusion along the backwaters is still a problem needing regular attention for effective management of water. The rich aquatic resources, particularly ornamental fishes, offer new opportunities to improve the economy of the region.

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