

Probable Agricultural Biodiversity Heritage Sites in India: XX. The Konkan Region

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Abstract

The Konkan region – consisting of the narrow strip of India’s northwestern Western Ghats and the coastal plains – is a region with rich agriculture heritage, where most of the people are involved in agriculture. The region is credited with the use of unique agricultural systems, such as the Gavkari joint land management system. Agriculture has been practiced in the region from ancient times; the contacts it had with the Africans, Arabs, Turks, Romans, etc., enabled the trade of agricultural produce such as spices, textiles, perfumes, etc., much before the advent of Western European culture. The trading continued during the medieval period, and played an important role in the introduction and adaptation of several exotic crops into India, revolutionizing Indian agrobiodiversity. At the same time, it facilitated the dispersal of Indian crops such as rice, spices, coconut to other parts of the world, enriching global agrobiodiversity. Cultivation of enriched agrobiodiversity under diverse high-rainfall microclimatic conditions led to the development of unique tropical mixed cropping systems, generation and conservation of rich genetic diversity in most crops, and the creation of new avenues for farmers’ livelihood support. For these contributions, the region is being proposed as another National Agricultural Biodiversity Heritage Site in India, based on the indices illustrated for identification of an agricultural biodiversity heritage site. The paper discusses some of these contributions in brief.

The Konkan region runs west of the Sahyadri mountains from the river Tapti to Kalinadi. In the ancient Hindu text *Skanda Purana*, the region has been described as the *Sapta-Konkan*, stretching from present-day Maharashtra to Karnataka. The region is part of the recently (2012) recognized UNESCO World Heritage Site, the Western Ghats, a global biodiversity hotspot rich in biodiversity and species endemism, besides several other sites like the Ajanta and Elephanta Caves, etc. Being on the windward

side of the Sahyadri mountains, it receives high rainfall. Consequent to its humid climate and rich biodiversity, it attracted human settlers from time immemorial from various parts of the world, including parts of the Indian subcontinent, starting with the Proto-Australoid, Indo-Aryans, Dravidians, and seaborne Sumerians, evolving a complex culture and agriculture. Agriculture is practiced in the region from ancient times on slopy mountains and fertile coastal plains, under diverse farming

systems. Centuries of settlement and agriculture in such a region have resulted in the domestication of economically important species, evolution of rice, fruit, and plantation crops-based production systems, including mixed cropping system with unique practices, generating significant genetic diversity in indigenous field crops such as rice; fruits such as coconut, areca nut, mango, and banana; and spices such as pepper. Being on the western coast of India with several entry ports, the Konkan was an important center of foreign trade and played an important role in the introduction of several exotic crops to the subcontinent, enriching the agricultural crop diversity, virtually bringing an agrobiodiversity revolution in the region/country. A number of these exotic crops have become an integral part of Indian agriculture, evolving a number of production systems without which the present agriculture of the region/country would be incomplete. For example, cashew nut, introduced by Portuguese to India through Goa, is contributing to the economy of the region and country, which is currently the largest producer in the world. The cultivation/adaptation of exotic and indigenous crop species under diverse agroecologies facilitated the enrichment of genetic diversity. Trade interactions also led to the dispersal of Indian crops to other parts of the world enriching global agrobiodiversity. For example, spices were carried by the Portuguese to Brazil for cultivation, and coconut and rice genetic diversity was dispersed. The Konkan region therefore deserves recognition for its contribution to enriching agrobiodiversity, evolving unique tropical production systems, generation

and conservation of rich genetic diversity both in indigenous and exotic crops, and strengthening the livelihood support of the farming community of the region and of the world at large with diversified/improved agriculture. The present article proposes the region as another National Agricultural Biodiversity Heritage Site based on the indices illustrated by Singh and Varaprasad (2008).

Location and extent

The precise extent of Konkan region varies, but according to most descriptions, it includes the lands between the northern Western Ghats and the Arabian Sea, and between the Tapti River in the north and the Chandragiri River in the south. The administrative areas falling in this region are: (i) in Maharashtra – the five western districts of Thane, Mumbai, Raigad, Ratnagiri, and Sindhudurg, including parts of Pune, Satara, and Kolhapur districts; (ii) the entire state of Goa; and (iii) in Karnataka – the *Karavali* area, which covers parts of the three coastal districts of Uttara Kannada, Udupi, and Dakshina Kannada (Fig. 1). Geographically, the Sahyadri mountain range of the northern Western Ghats forms the eastern boundary of the Konkan region, and the Arabian Sea marks the western boundary, while the Tapti River forms the northern boundary, and the Chandragiri River the southern boundary, though agricultural influence may extend beyond these physical boundaries. Agroecologically, it will include the windward side of the northern Western Ghats that is the crest of the Sahyadri ranges and the coastal plains. On the map of India, the region appears as a narrow strip, west

of the Sahyadri, running south of the river Tapti to Kalinadi in Karnataka and a little beyond (Fig. 1).

Landscape

Lying between the Arabian Sea and the Sahyadri Range, the Konkan region is a narrow coastal lowland, barely 50 km wide with steep cliffs. It has a slopy terrain and highly percolative Lateritic soil. Historically,

it evolved by tectonic uplift due to the collision of the Indian and Eurasian plates. Due to the collision, it produced variation in the landscape from open beaches to the areas surrounded by hills. The western extension of the uplifted landmass was submerged under the Arabian Sea. This narrow coastal belt is arranged in step-like terraces, pointing to recent oscillations in the sea level and of submergence as evident from the drowned valleys, lagoons,



Figure 1. Location and extent of the Konkan region.

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and sand bars. Wave cut cliffs and plate forms are also common along the coastline indicating changes in sea levels. Though the altitude is mostly below 200 m, it is far from being a plain. It is highly dissected and broken; the landscape alternates between narrow, steep-sided valleys and low lateritic plateau. The general topography, therefore, is characterized by undulating hilly tract, mostly less than 300 m in altitude, dotted with dense forests, white sand beaches with clean sea water, greenery of palm trees and paddy fields, coconut groves and mango orchards. Mahabaleshwar and Harischandragad are the important peaks.

The Konkan region therefore deserves recognition for its contribution to enriching agrobiodiversity, evolving unique tropical production systems, generation and conservation of rich genetic diversity both in indigenous and exotic crops, and strengthening the livelihood support of the farming community of the region and of the world at large with diversified/improved agriculture.

Agroclimate

Agroecologically, the Konkan region is part of the hot humid-perhumid ecoregion consisting of the Sahyadri mountain range and the western coastal plains, extending over the states of Maharashtra, Goa, Karnataka, and Kerala (Sehgal *et al.*, 1992). It is characterized by tropical or tropical like climate, with hot to mild summers and mild winters. This type of weather can be called equitable, without much variation between hot and cold seasons. The region gets about 2,072–3,800 mm annual average rainfall. The western slopes of the Sahyadri mountains experience heavy rains, while the southern parts receive very heavy rains, going up to 4,000 mm, 90 per cent of which is received from June to October (100–110 days). For these reasons, the region has a long growing period extending to more than 270 days. The relative humidity varies from 90 to 95 per cent in the *kharrif*, and 80 to 85 per cent in the *rabi* season, while the maximum and minimum temperatures are 30 to 31°C and 22 to 24°C respectively. Despite the heavy rainfall, scarcity of water during the summer months (February to April) is common.

The major soils of the region include Red and Lateritic soils of the Sahyadri mountains and alluvium-derived soils of the coastal plains. The Red soils are formed from mixed parent material such as granite, gneiss, schist, trap, etc. The Lateritic soils are of three types: rice soils, *warkas* (light) soils, and garden soils. On the hills, the slopes are coarse and the soils are sandy in nature, while in the valleys they are clay loams. The clayey soil is acidic in nature and

poor in base saturation. The coastal plains have alluvium soil, which is more silty and sandy in nature.

Floristic diversity

The climatic condition of the Konkan region has supported rich floristic diversity with a high level of rare and endemic plant species, contributing to the overall biodiversity of the Western Ghats, one of the eight hottest global biodiversity hotspots, and one of the three mega-centers of species endemism in India (Nayar, 1996). Nayar (1996) divided the mega endemic areas of the Western Ghats into two mega-centers, the Northern Western Ghats and the South Western Ghats. At the national level, Nayar (1996) considered Mahabaleshwar (Khandala ranges representing the main Sahyadris) and Konkan (Raigad) among 25 micro-centers of species endemism in the country. As the region falls on the windward side of the Northern Western Ghats, receiving maximum rainfall, it supports moist deciduous forests with pockets of **evergreen type of forests**. However, the evergreen trees are characteristically dwarfed, not having typical canopies of evergreen tropical forests (Qureshi, 1965). The other forest types found in the region are semi-evergreen forests, montane (cloud or fog) subtropical evergreen forests, dry deciduous forests, scrub forests, and grasslands. The **semi-evergreen forest** consists of *Albizia lebbek* (L.) Benth., *Elaeocarpus serratus* L., *Holigarna arnottiana* J.Hk, *Lagerstroemia lanceolata* Wall., *Macaranga peltata* (Roxb.) Mueller, *Sterculia guttata* Roxb., *Syzygium cumini* (L.) Skeels, *Terminalia bellirica* Roxb., and

T. chebula Retz. The **tropical deciduous forest** is represented by *Careya arborea* Roxb., *Dillenia pentagyna* Roxb., *Canthium dicoccum* (Gaertn.) Merr., *Macaranga peltata*, and *Pterocarpus marsupium* Roxb. The **dry deciduous forests** have some of the following important species: *Acacia chundra* Willd., *Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guill., *Butea monosperma* Roxb. ex Willd. (*khakara*), *Cassia fistula* L., *Dalbergia latifolia* Roxb., *Haldina cordifolia* (Roxb.) Ridsd., *Lagerstroemia parviflora* Roxb., and *Sterculia urens* Roxb. The **scrub forest** species are represented by *Acacia chundra*, *A. nilotica* (L.) Delile var. *indica* (Benth.) A.F. Hill, *Barleria prionitis* Linn., *Carissa congesta* Wight (syn. *C. carandas* Auct.), *Capparis divaricata* Lam., *Dichrostachys cinerea* (L.) Wight & Arn., *Flacourtia indica* (Burm.f.) Merr., and *Holarrhena pubescens* Wall. ex G. Don. The marshy areas and the swampy places near the sea are occupied by the mangrove bushes. The dominant species of mangrove are *Avicennia* L. spp., *Rhizophora* L. spp., *Ceriops* Arn. spp., *Lumnitzera* Willd. spp., *Aegiceras* Gaertn. spp., *Excoecaria* L. spp., etc.

Agriculture and agrobiodiversity

Rainfed agriculture is commonly practiced in the region. Lands in the Maharashtra area are divided into *Garva* lands (with good water), *Neem-Garva* lands (with medium water holdings), and *Halva* lands (with poor soil). Agroclimatically, there are three seasons: *monsoon* from June to September, with heavy rainfall referred as *kharif*; *winter* from October to February, with relatively

less temperature and humidity, referred as *rabi*; and *summer* from March to June, hot and humid, with April being the hottest. Major traditional agricultural crops include rice, millets, pulses among field crops, and coconut, mango, cashew nut, betel nut, *aonla*, vanilla, pineapple, etc. among horticultural crops.

Oilseeds and pulses were the most common native crops of the region. But now rice is the main crop, both in *karif* and *rabi* under irrigated conditions, predominantly in the coastal plains and even in the uplands. *Ragi* (finger millet), *vari* (little millet), proso millet (*cheena*), *jowar*, and *tur* (pigeonpea) are grown on the slopes, particularly in hilly areas on marginal soils during *kharif*. The Konkan region of Maharashtra obtains maximum productivity in the state, contributing to 42.91% of the total rice production. The traditional rice-growing districts are Thane, Raigad, Ratnagiri, and Sindhudurg. Pulses such as horse gram and *urad* are traditionally grown on residual moisture during the postrainy or *rabi* season. Oilseeds such as niger, sesame, and groundnut are cultivated during summer. Vegetables such as brinjal and cucurbits are grown in *kharif* or summer. The perennial fruit crops are cultivated on plantations.

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The common plantation crops are mango, coconut, areca nut, cashew nut, jackfruit, banana, pineapple, *chikoo* (sapota), and spices such as clove, nutmeg, and pepper.

With the intensification of agriculture, *kharif* has intensive cultivation of rice along with minor millets (proso millet, finger millet), pulses (green gram, cowpea, soybean), and vegetables such as okra, snake gourd, sponge gourd, ridge gourd, and pumpkin. *Rabi* has *rabi-jowar*, sugarcane, oilseeds such as sesame, mustard, and groundnut, and pulses such as horse gram, cowpea, lablab bean, moth bean, etc., grown on residual moisture. Vegetables such as kohlrabi, amaranths, radish, spinach, brinjal, kidney beans, and bitter gourd, and muskmelon and watermelon extend into the summer. Pulses and vegetables are the major components of most traditional mixed cropping systems.

For cultivation of rice, *Ulkatni* and *Awatni* are two local practices followed in the *Khar* (salty) lands of Thane and Raigad districts. In *Ulkatni*, the clods are turned upside down with the help of a crowbar in April–May, while *Awatni* is the practice of putting the rice seedlings in the field along with the mud ball from the seedbed (transplantation) (Fig. 2). It was observed that both the methods of preparatory tillage were effective. Hence, instead of *Ulkatni*, which was done manually, plowing could be done after the harvest of *kharif* rice in reclaimed *Khar* lands. *Awatni* was significantly superior to the regular practice of transplanting, provided the plant population is maintained. Superficial planting in *Awatni* avoids contact of the tender seedlings with the salty portion

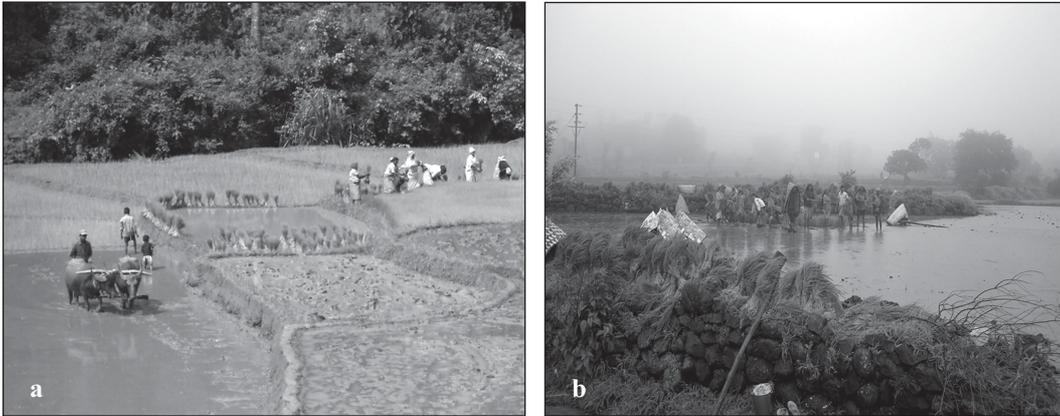


Figure 2. Transplantation of rice in the region: (a) irrigated; and (b) rainfed (Courtesy Dr DK Kulkarni).

of the soil, avoiding seedling mortality. Intensification of paddy cultivation in Karnataka area of the region has resulted in cultivation of paddy throughout the year in three seasons, *Karthika* or *Yenel* (May–October), *Suggi* (October–January), and *Kolake* (January–April).

In recent times, the popular rice varieties grown in the region with the transplanting method are: Karjat-184, Karjat-3, Karjat-5, Karjat-7, Palghar 1, Panvel 1, Ratnagiri 24, Ratnagiri 1, Ratna, Jaya, Mahsuri, Sahyadri, Sahyadri-2, Sahyadri-3, Sahyadri-4, Suruchi, Swarna, Gujrat-11, and Rupali. The common rice-based cropping systems are: (1) irrigated: rice–rice, groundnut, mustard, maize, vegetables; rice–rice, groundnut, pulses, vegetables; rice–chickpea, lentil, peas, wheat, mixed pulses, vegetables; and (2) rainfed: rice–fallow, *Dolichos* bean, horse gram, pigeonpea, green gram, chickpea, and cowpea.

The heavy rainfall, hot and humid climate, well drained soils, and mountainous

undulating and slopy terrain make the region favorable for horticultural crops, particularly the plantation crops of various fruits, and the coastal agro-aqua farming. Therefore, the region is predominantly a horticultural zone of Maharashtra (Thorat *et al.*, 2006). The fruit crops give four to five times more return per unit area than the traditional cereals. Mango, cashew nut, kokum, jackfruit are the major rainfed plantation fruit crops, while coconut, areca nut, sapota are the major irrigated plantation crops. Coconut is a small holder's plantation crop, cultivated as an allied crop in varied

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crop-mix. About 92 per cent of the total area of the region is under coconut farming. Most coconut plantations are of the variety West Coast Tall (WCT), dwarf varieties such as Andaman Dwarf, Nicobar Dwarf, Laccadive tall and dwarf, and hybrid varieties, Tall \times Dwarf, Dwarf \times Tall, besides planting of the hybrid VHC-1.

Though introduced around 300 years ago, cashew nut has become the traditional crop of the region, mainly grown on hill slopes as a rainfed perennial horticultural crop. In recent times, in the upper Laterite zones, cassava (introduced) is also cultivated. Consequent to predominant plantation crops cultivation, several mixed cropping systems have evolved (Fig. 3). The ornamental crops grown in the region are *mogra* (jasmine), *jai*, *Hibiscus*, *sayali*, *kagda*, and yellow champak.

Livestock rearing and fishing are the other flourishing agricultural practices. In livestock, the concentration is mainly on small animals. For example, the *Dhangar* and *Maratha* communities rear the *Konkan*



Figure 3. Tropical climate with heavy rainfall supporting rice and horticulture crops (Source: Suprioghatak.blogpost.com).

Kanyal goat for meat (Fig. 4). Fishing is a flourishing business because the coast and creeks are rich in marine resources of shrimp, crabs, prawns and many kinds of fishes such as mullet, seahorse, ornamental fishes, etc., besides the giant freshwater prawn (Fig. 5). Fishing can be classified into fresh water, creek, and sea fishing.

Consequent to the cultivation of diverse crops and farming systems, such as rearing of livestock for milk and meat, poultry, etc., Torane (2009) found 18 major farming systems being practiced in different areas of the region, as per the microclimate and resources: (1) paddy + irrigated plantations + dairy; (2) paddy + grass + dairy + goat rearing; (3) paddy + irrigated plantations + flowers; (4) irrigated plantations + dairy; (5) paddy + irrigated plantations + betelvines; (6) paddy + other cereals + rainfed plantations + dairy; (7) paddy + other cereals + dairy + goat rearing; (8) paddy + pulses + dairy; (9) paddy + vegetables + poultry; (10) paddy



Figure 4. The *Konkan Kanyal* goat breed evolved under the hot, humid and high rainfall conditions of the region (Source: www.dbskkv.org/research/research_rsi_nileli.html).



Figure 5. (a) The long coastline of the Konkan region gifted with diverse marine resources (Source: purnatravels.blogpost.com); and (b) Local fishermen at work (Source: www.flickr.com).

+ grass + dairy; (11) paddy + vegetables + dairy; (12) paddy + dairy; (13) paddy + dairy + goat rearing; (14) paddy + pulses + dairy + poultry; (15) paddy + rainfed plantations + dairy; (16) paddy + irrigated plantations + rainfed plantations + dairy; (17) paddy + irrigated plantations + vegetables + dairy; and (18) paddy + irrigated plantations + rainfed plantations + poultry.

Representative crop species in various crop groups

Cereals, pseudocereals, and millets. *Bajra* or pearl millet [*Pennisetum glaucum* (L.) R. Br.; syn. *P. typhoides* (Burm. f.) Stapf & C. E. Hubb.], *cheena* or proso millet (*Panicum miliaceum* L.), finger millet [*Eleusine coracana* (L.) Gaertn.], foxtail millet [*Setaria italica* (L.) Beauv], *kang* [*S. pallidifusca* (Schumach.) Stapf & C. E. Hubb.; syn. *S. pumila* (Poir.) Roem. & Schult. subsp. *pallidifusca* (Schumach.) B. K. Simon], *makra* [*Dactyloctenium aegypticum* (L.) Willd.] poor/famine food, *Pennisetum orientale* Rich. (cooked as rice), rice (*Oryza sativa* L.), sorghum [*Sorghum*

bicolor (L.) Moench], and *vari* or little millet (*Panicum sumatrense* Roth.; syn. *P. miliare* auct. non Lam.).

Grain legumes and oilseeds. Black gram [*Vigna mungo* (L.) Hepper; *V. mungo* (Linn.) Hepper var. *sylvestris* Lukoki, Marechal, & Otoul.], chickpea (*Cicer arietinum* L.), cowpea (*Vigna unguiculata*), green gram [*Vigna radiata* (L.) R. Wilczek, *V. radiata* var. *setulosa* (Dalzell) Ohwi & Ohashi], groundnut (*Arachis hypogaea* L.), horse gram [*Macrotyloma uniflorum* (Lam.) Verdc.], jack or sword bean [*Canavalia gladiata* (Jacq.) DC.], lablab bean [*Lablab purpureus* (L.) Sweet], lentil (*Lens culinaris* Medikus), mustard [*Brassica juncea* (L.) Czern.], niger [*Guizotia abyssinica* (L.f.) Cass.], pigeonpea (*Cajanus cajan*

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L. Millsp.), *pillipesara* [*Vigna trilobata* (L.) Verdc.], rice bean [*Vigna umbellata* (Thunb.) Ohwi & H. Ohashi], sesame (*Sesamum indicum* L.), and soybean [*Glycine max* (L.) Merr.].

Fodder and fiber crops. *Albizia lebbeck*, *Apluda mutica* L., *Aristida adscensionis* Linn., *Chloris dolichostachya* Lag., *C. virgata* Swartz., *Chrysopogon fulvus* (Spreng.) Chiov., *Dactyloctenium aegyptium* (L.) Willd., *Desmostachya bipinnata* (L.) Stapf. (weed), *Echinochloa colona* (L.) Link (*bhagar* or *vari cha tandul* used as food too), *Eragrostis ciliaris* (L.) R.Br. (soil binder), *E. unioloides* (Retz.) Nees ex Steud., *Gliricidia sepium* (Jacq.) Kunth ex Walp. (in wet areas), *Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult. (syn. *Andropogon contortus* L.), *Leucaena leucocephala* (Lam.) de Wit, *Mucuna pruriens* (L.) DC., *Paspalidium flavidum* (Retz.) A. Camus, *Pennisetum pedicellatum* Trin., *Perotis indica* (L.) Kuntze, *Pueraria montana* (Lour.) Merr. var. *lobata*, and *Sehima sulcatum* (Hack.) A. Camus. Several of these are harvested from nature.

Vegetables. *Bhindi* [*Abelmoschus esculentus* (L.) Moench], bitter gourd (*Momordica*

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charantia L.), bottle gourd [*Lagenaria siceraria* (Molina) Standley], brinjal (*Solanum melongena* L.), chili (*Capsicum annuum* L.), cucumber (*Cucumis sativus* L.), *Flemingia macrophylla* (Willd.) Merr. (pods edible), horse gram [*Macrotyloma uniflorum* (Lam.) Verdc.], *kharbuj* (*Cucumis melo* L.), *kundri* [*Coccinia grandis* (L.) Voigt; syn. *C. indica* Wight & Arn.], *Lens culinaris* (young pods), *Ougeinia oojeinensis* (Roxb.) Hochr. (flowers edible), pumpkin (*Cucurbita pepo* L.), ridge gourd [*Luffa acutangula* (L.) Roxb.], snake gourd (*Trichosanthes anguina* L.), and spine gourd (*Momordica dioica* Roxb. ex Willd.).

Leafy vegetables. Amaranths [*Amaranthus hybridus* L., *A. cruentus* L. (syn. *A. paniculatus* L.), *A. polygamus* L. (syn. *A. tricolor* L.), *A. spinosus* L.], *basale* (*Basella alba* L.), and *Corchorus depressus* (Linn.) Stocks (leaves as pot herb).

Bulb and tuber crops. *Amorphophallus konkanensis* Hett., S.R.Yadav & K.S.Patil, *A. sylvaticus* (Roxb.) Kunth., *Dioscorea esculenta* (Lour.) Burk., *Flemingia procumbens* Roxb. [syn. *Moghania vestita* (Baker) Kuntze], *chavar* or Indian arrowroot [*Hitchenia caulina* (J. Graham) Baker.; syn. *Curcuma caulina* J. Graham.] (rhizome yields starch), Indian kudzu [*Pueraria tuberosa* (Roxb. ex Willd.) DC.P.], potato

(*Solanum tuberosum* L.), *sherla* or dragon stalk yam [*Amorphophallus commutatus* (Schott) Engl.], sweet potato [*Ipomoea batatas* (L.) Poir.], taro [*Colocasia esculenta* (L.) Schott], cassava (*Manihot esculenta* Crantz), and yam (*Dioscorea bulbifera* L.; syn. *D. sativa* L.).

Fruits. *Aonla* (*Embllica officinalis* Gaertn.; syn. *Phyllanthus emblica* Wall. ex Stapf.), Cavendish banana (triploid *Musa acuminata* Colla; *M. sapientum* L.), *chikoo* or sapota [*Manilkara zapota* (L.) P.Royen; syn. *Achras zapota* L.], citron (*Citrus medica* L.), wood-apple (*Limonia acidissima* Linn.), *Gunnamada patteballi* (*Elaeagnus latifolia* L.), jackfruit (*Artocarpus heterophyllus* Lam.), *jamun* or *jambhul* [*Syzygium cumini*; syn. *Eugenia jambolana* Lam.], *karvandas* or *karonda* (*Carissa congesta*; syn. *C. carandas*), *khirni* [*Manilkara hexandra* (Roxb.) Dubard], *kokum* [*Garcinia indica* (Linn.) Robs.], litchi (*Euphoria longan* Stued.), mango (*Mangifera indica* L.), *maulsari* (*Mimusops elengi* L.), papaya (*Carica papaya* L.), pineapple [*Ananas comosus* (L.) Merr.], *sitaphal* or custard apple (*Annona squamosa* L., *A. cherimola* Mill.), *Rosa leschenaultina* Red. & Thory ex Wt. & Arn., *Spondias pinnata* (L. f.) Kurz, strawberry (*Fragaria nilgerrensis* Schecht.), tamarind (*Tamarindus indica* L.), and *Ziziphus glabrata* Heyne ex Roth.

Spices. Black pepper (*Piper nigrum* L.), chili (*Capsicum annuum* L.), cinnamon (*Cinnamomum verum* J.Presl; syn. *C. zeylanicum* Blume), *Kaempferia galanga* L., ginger (*Zingiber officinale* Roscoe), *kalajira* (*Carum strictocarpum* C.B.Clarke), nutmeg (*Myristica malabarica* Lamk., *M.*

dactyloides Gaertn.), turmeric (*Curcuma longa* L.; syn. *C. domestica* Valet., *C. brog* L.), and vanilla (*Vanilla planifolia* Jacks. ex Andrews; syn. *V. fragrans* Ames).

Plantation crops. Areca nut (*Areca catechu* L.), cashew nut (*Anacardium occidentale* L.), coconut (*Cocos nucifera* L.), coffee (*Coffea arabica* L., *C. canephora* Pierre ex A.Froehner; syn. *C. robusta* Linden), and *pan* or *betel vine* (*Piper betel* Linn.).

Ornamentals. *Vjradanti* (*Barleria prionitis* L.) (also medicinal), crinum lily (*Crinum woodrowii* Baker) (rare), *Delphinium malabaricum* var. *ghaticum* (Huth) Munz., doum palm [*Hyphaene thebaica* (L.) Mart., *H. dichotoma* (White) Furtado.], *Garcinia indica* (in landscaping), *Hibiscus* L. spp., *Ixora singaporensis* Linn., *Jacaranda acutifolia* Humb. et Bonpl. (introduction), *jakandil kharchudi* or *kandil pushpa* (*Ceropegia fantastica* Sedgw.), *karnaphul* or lily (*Crinum brachynema* Herb.), *karvi* (*Carvia callosa* (Nees) Bremek.), *mogra* (*Jasminum* L. spp.), *nori karnaphul* (*Crinum eleonorae* Blatt. & McCann.), *Rosa leschenaultina*, *shindal makudi* (*Frerea indica* Dalz.), *sugandhi* or ginger lily (*Hedychium coronarium* J. Koenig.) (also medicinal), and yellow champak [*Magnolia champaca* (L.) Baill. ex Pierre; syn. *Michelia champaca* L.].

Dye-yielding plants. *Acacia catechu* (L.f.) Willd. (heartwoods), *A. nilotica* (barks), *A. nilotica* var. *indica* (leaves), *Caesalpinia pulcherrima* (L.) Swartz (flowers), *Embllica officinalis* (leaves), *Hardwickia binata* Roxb., *Hibiscus rosa-sinensis* L. (flowers), *Lawsonia inermis* L. (leaves), *Mallotus*

philippensis (Lamk.) Muel (capsules), *Memecylon umbellatum* Burm.f., *Symplocos racemosa* Roxb., and *Syzygium cumini*.

Medicinal and aromatic plants. A significant amount of knowledge has been generated on medicinal properties of plants of the region (Upadhye *et al.*, 1994) and against specific diseases. For example, for gastrointestinal disorders, a recent survey found the use of *Aloe barbadense* Mill., *Ceropegia hirsuta* Wight & Arn., and *Cicer arietinum*, and *Anisochilus carnosus* for stomachache, *Citrus aurantifolium* for dysentery, and *Zingiber officinalis* for acidity and ulcers (Kamble *et al.*, 2008). Other plants commonly used for medicinal purposes are *aghada* (*Achyranthes aspera* L.) (found as weed), *Aloe vera* (L.) Burm. f. (syn. *A. barbadensis* Mill.), *kalmegh* [*Andrographis echioides* (L.) Nees], *Anisochilus carnosus* (L.f.) Wall. (natural), *apta* (*Bauhinia variegata* L.), *Chlorophytum tuberosum* Baker, *Cissus quadrangularis* L., *Cissus repanda* Vahl, *Cymbopogon martini* (Roxb.) W. Watson, *C. nardus* (L.) Rendle, *C. citratus* Stapf, *hirda* (*Terminalia chebula*), *madhunashini* (*Gymnema sylvestre* R.Br.), *safed musli* (*Chlorophytum borivilianum* L.), and *tulasi* (*Ocimum tenuiflorum* L.).

Timber and bamboos. Timber: *Albizia chinensis* Merr., *Canarium strictum* Roxb., *Chloroxylon swietenia* DC., *Chukrasia tabularis* A. Juss., *Dipterocarpus indicus* Bedd., *Hopea parviflora* Bedd., *Lagerstroemia microcarpa* Wight, *Mesua ferrea* L., *Palaquium ellipticum* Engl., *Tectona grandis* L.f., *Toona ciliata* M.Roem.; bamboo: *Bambusa bambos* (L.) Voss. [syn. *Bambusa arundinacea* (Retz.)

Willd.], *Dendrocalamus strictus* Nees, *Pseudoxytenanthera ritcheyi* (Munro) H.B.Naithani.

Multipurpose species. *Acacia nilotica*, *Anogeissus latifolia*, *Boswellia serrata* Roxb., *Pterocarpus marsupium*, *Sterculia urens* Roxb. (wood, gum, and resin), *Morus alba* L. (syn. *M. australis* Poir.; fruit and silkworm rearing), *Diospyros melanoxylon* Roxb. (*tendu*; leaves for *beedi* making), and *Vateria indica* L. (bark resin, natural incense, medicinal).

Wild relatives of crop species. *Abelmoschus angulosus* Wall. ex Wight & Arn., *A. ficulneus* (L.) Wight & Arn., *A. manihot* (L.) Medik. subsp. *manihot*, *Cajanus lineatus* (Wight & Arn.) Maesen, *C. sericeus* (Baker) Maesen, *Canavalia lineata* (Thunb.) DC., *Cinnamomum goaense* Kosterm., *Coffea wightiana* Wight & Arn., *C. crassifolia* Gamble, *Cucumis ritchei* (Chakr.) Jeffrey, *C. setosus* Cogn., *Curcuma indora* Blatt., *C. pseudomontana* J. Graham, *C. purpurea* Blatt., *C. reclinata* Roxb., *Dolichos bracteatus* Baker [syn. *Sphenostylis bracteata* (Baker) Gillett], *Echinochloa colona*, *Garcinia malabarica* Talbot, *G. morella* (Gaertn.) Desr., *G. talbotii* Raiz. & Sant., *Mangifera sylvatica* Roxb., *Momordica tuberosa* (Roxb.) Cogn. (syn. *M. cymbalaria* Hook. Fenzl ex Naud.), *Oryza meyeriana* (Zoll. & Moritzi) Baill. (syn. *O. indandamanica* J.L.Ellis), *Panicum hippothrix* K.Schum. ex Engl., *Pennisetum orientale*, *Piper argyrophyllum* Miq., *P. galeatum* C.DC., *P. hookeri* Miq., *P. hymenophyllum* Miq., *P. trichostachyon* DC., *Vigna dalzelliana* (Kuntze) Verdc., *V. khandalensis* (Santapau) Raghavan &

Wadhwa (syn. *V. grandis* Dalz. & Gibbs.), *Zingiber neesatum* (Grah.) Ramamoorthy (syn. *Z. macrostachyum* Dalz.), and *Z. purpuram* Roxb. (medicinal).

Endemic species. The region is one of the mega-centers of species endemism from Western Ghats with many species belonging to *Ceropegia* L., *Crinum* L. (lily), *Dichanthium* Willem., *Eriocaulon* L., and *Isachne* R.Br. strictly confined to the region (Nayar, 1996). The economic/agriculturally important species listed from the region include *Abutilon ranadei* Woodrow & Stapf, *Amorphophallus konkanensis* Hett., *Asparagus laevisissimus* Steud., *Carvia callosa* (Nees) Bremek., *Cassia kolabensis* Kothar *et al.*, *Ceropegia attenuata* Hook., *C. evansii* McCann, *C. huberi* Ansari, *C. maccannii* Ansari, *Chlorophytum bharuchae* Ansari & Raghavan, *Crinum brachynema*, *C. woodrowii* Baker, *Cucumis ritchei*, *Cucumis setosus*, *Curcuma purpurea*, *Dalbergia horrida* (Dennst.) Mabb. var. *concanensis* Thoth., *Delphinium malabaricum* (Huath.) Mung. var. *ghaticum* Billore, *Dendrobium lawianum* Lindl., *D. ovatum* Kraenzl. (orchid), *Dichanthium maccannii* Blatt., *D. panchganiense* Blatt. & McCann, *D. paranjpyeanum* (Bhide) Clayton (and many more *Dichanthium* spp.), *Diospyros paniculata* Dalz., *Garcinia indica* (Dupetit-Thours) Choiss., *G. tallbotii*, *Habenaria gibsonii* var. *gibsonii*, *H. panchganiensis* Santapau & Kapadia (orchid), *Iphigenia stellata* Blatt., *Ischaemum* L. spp. of tropical grasses, *Lavandula lawii* Wight, *Urochloa panicoides* P. Beauv. var. *marathensis* (Henr.) Bor, *Vigna khandalensis* (Sant.) Raghavan & Wadhwa, *V. trilobata* (L.) Verd. var. *pusilla* Naik & Pokle, *V. vexillata* (L.) A.

Rich var. *sepiaria* (Dalz.) Babu & Sharma, *V. vexillata*. (L.) A. Rich var. *stocksii* Benth ex Baker, and *Zingiber cernuum* Dalz. Table 1 lists the representative economic endemic species from the region.

Threatened species. The Red Data Book of Plants of India (Nayar and Sastry, 1987–90) lists economically/agriculturally important species of the Konkan region, such as *Abutilon ranadei*, *Achyranthes coynei* Santapau, *Aglaia lawii* (Wight) Saldanha ex Ramamoorthy, *Aglaia talbotii* Sundararagh., *Aponogeton satarensis* Sundararagh., A.R.Kulk. & S.R.Yadav, *Asparagus jacquemontii* Baker, *Barleria gibsonioides* Blatt., *Bhidea burnsiana* Bor, *Bidaria khandalensis* (Santapau) A.P.Jagtap & N.P.Singh, *Cajanus lineatus* (Wight & Arn.) Maesen, *Calamus brandissi*, *Ceropegia attenuata*, *C. lawii* (and many more *Ceropegia* spp.), *Crinum woodrowii* (and many more *Crinum* spp.), *Crotalaria bidiei* Gamble, *C. filipes* Benth. var. *filipes*, *C. stocksii* Benth. ex Baker, *Chlorophytum borivilianum*, *Delphinium malabaricum* var. *ghaticum*, *Dichanthium armatum*, *D. compressum*, *Elaeocarpus minorii* J.Graham (rudraksha), *Euphorbia panchganiensis* Blatt. & McCann, *E. katrajensis* Gage (veterinary medicine), *Frerea indica* Dalzell, *Garcinia tallbotii*, *Ipomoea clarkei* Hook. f., *Isonandra montana* (Thw.) Gamble, *Paracautleya bhattii* R.M.Sm., *Pimpinella katrajensis* R.S.Rao & Hemadri, *P. rollae* K.V.Billore & Hemadri, *Syzygium bourdillonii* (Gamble) Rathakr (syn. *Jambosa bourdillonii* Gamble), *S. stocksii* (Duthie) Gamble, *Typhonium incurvatum* Blatt. & McC., *Vepris bilocularis* Engl.,

Table 1. Representative economic endemic plant species from the Konkan region.¹

Plant species	Family	Habit	Distribution	Remarks
<i>Amorphophallus konkanensis</i>	Araceae	Cormous herb	Konkan	Food
<i>Carvia callosa</i>	Acanthaceae	Tall shrub	Konkan Western Ghats	Source of Carvia honey
<i>Ceropegia evansii</i>	Asclepiadaceae	Herb	Konkan	Ornamental
<i>Ceropegia huberi</i>	Asclepiadaceae	Herb	Konkan	Ornamental
<i>Ceropegia maccanni</i>	Asclepiadaceae	Twining herb	Konkan	Ornamental
<i>Chlorophytum borivilianum</i>	Liliaceae	Herb	Northern Western Ghats	Medicinal value of tubers
<i>Crinum brachynema</i>	Amaryllidaceae	Bulbous herb	Northern Western Ghats	Medicinal
<i>Cucumis ritchei</i>	Cucurbitaceae	Scandent herb	Northern Western Ghats	Genetic resource
<i>Curcuma purpurea</i>	Zingiberaceae	Rhizomatous herb	Konkan	Spice, genetic resource
<i>Dendrobium lawianum</i>	Orchidaceae	Herb	Konkan	Ornamental
<i>Dendrobium ovatum</i>	Orchidaceae	Herb	Konkan	Ornamental
<i>Dichanthium concanensis</i>	Poaceae	Herb	Konkan	Grass, genetic resource
<i>Diospyros paniculata</i>	Ebanaceae	Tree	Northern Western Ghats	Wood, matchbox making
<i>Garcinia indica</i>	Cluseaceae	Tree	Northern Western Ghats	Kokum butter, fruit
<i>Habenaria panchganiensis</i>	Orchidaceae	Herb	Northern Western Ghats	Ornamental
<i>Vigna trilobata</i>	Fabaceae	Herb	Northern Western Ghats	Fodder, genetic resource
<i>Vigna vexillata</i> var. <i>sepiaria</i>	Fabaceae	Herb	Northern Western Ghats	Fusiform tuber is edible

1. Source: Nayar (1996).

Vateria indica, *Vigna khandalensis* (syn. *V. grandis*), *Zingiber cernuum*, and *Z. neesanum* (Grah.) Ramam. Some representative economic species under threat are presented in Table 2.

Associated culture and tribes

It is believed that the tribes of Austric origin such as the *Kols*, *Mundaris*, *Kharvis* had settled in the Konkan area and Goa during

Table 2. Representative economic plant species under threat in the Konkan region.¹

Species	Family	Habitat	Threat status ²	Remark
<i>Abutilon ranadei</i>	Malvaceae	Undershrub	CR	Endemic, medicinal, wild
<i>Cajanus lineatus</i>	Fabaceae	Shrub	I or DD	Genetic resource of pigeonpea
<i>Calamus brandissi</i>	Arecaceae	Scandent shrub	R	Used in construction
<i>Ceropegia attenuata</i>	Asclepiadaceae	Herb	R	Endemic, ornamental, genetic resource
<i>Crinum eleonorae</i>	Amaryllidaceae	Herb	Possibly Ex	Endemic, medicinal
<i>Crinum woodrowii</i>	Amaryllidaceae	Herb	Rare/CR	Endemic, rediscovered
<i>Delphinium malabaricum</i> var. <i>ghaticum</i>	Ranunculaceae	Perennial herb	I or DD	Endemic, ornamental, genetic resource
<i>Vigna khandalensis</i> (syn. <i>V. grandis</i>)	Fabaceae	Herb/undershrub	R	Endemic, seed eaten in scarcity, genetic resource
<i>Zingiber cernuum</i>	Zingiberaceae	Herb	I or DD	Endemic, genetic resource
<i>Zingiber neesanum</i>	Zingiberaceae	Herb	I or DD	Genetic resource

1. Source: Nayar and Sastry (1987–90); Nayar *et al.* (2009).

2. CR = Critically endangered; Ex = Extinct; I or DD = Indeterminate or Data deficient; R = Rare.

the Neolithic period, around 3,500 BCE, living on hunting, fishing, and a primitive form of agriculture. During the Neolithic period also came the Negroids. They were basically food-gatherers. Agriculture was just shaping up at that time. Later, after the drying up of the mighty Sarasvati River, came the Indo-Aryans who settled in the region around 2,400 BCE, and then around 1,775 BCE, the seaborne community of Sumerian Phoenicians. The Sumerians introduced the *Gavkari* system, whose main feature was that the village lands belonged to the village gods or goddesses. The agricultural land was jointly owned by the group of villagers, who had the right to auction or rent the land, which was used for development, and the remaining was distributed amongst the *Gavkars* (followers). The system had

records of boundaries of land from village to village with its topographic details, along with management, social, religious and cultural interactions details. It is still prevalent in some parts of Goa. The second wave of Indo-Aryans occurred between 1,700–1,400 BCE, and was accompanied by the Dravidians from the Deccan plateau, and probably by the *Kusha* or Harappan people from Lothal around 1,600 BCE, consequent to the submergence of their civilization, which thrived on sea-trade. This admixture of several cultures, customs, religions, dialects, and beliefs brought a revolutionary change and complexity in early Konkani society. The name *Kongvan* or *Konkan* was probably derived from the *Konkas* tribe of Proto-Australoid origin. Later, migration from the east during the Maurya era marked the

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advent of Buddhism. Introduction of Jainism, patronizing of Shaivism, use of Sanskrit and Kannada and overseas trade contacts with Africans, Arabs, Turks, Greeks, Romans, etc. had an overwhelming impact on the people of the region. During the medieval period (13th–15th century), Goa was ruled by the Bahmani Sultanate, bringing Muslim culture. Portuguese rule of Goa (1510–1812), brought Christianity to the region, creating greater cultural complexities.

Most residents of the region are called *Konkanis*, and they speak an Indo-Aryan language, *Konkani*, which also uses the written letter in the *Devanagari* script. The other major ethnic groups of the region are the *Tuluvas*, living in the coastal districts of Karnataka, Uttara Kannada, Udupi, and Dakshina Kannada; they speak Tulu and use Kannada script to write. The main tribes from the northwestern area in Maharashtra are *Bhilla*, *Warli*, *Thakar*, *Kokana*, *Gamita* (*Gavit*), *Kathkari*, *Kathodi*, *Mahadeo Koli*, *Koli-dhor*, *Dhangar*, *Dangar-koli*, etc. These tribes are involved in cultivation and other agriculture-related activities, particularly the *Dhodia*, *Konkas*, and *Warli* and the small group of *Koli*, *Kathodi*, *Naika*, and *Dubla*. *Warli* is the dominant community with beliefs focusing on nature, considered

as the Mother Goddess. Their paintings are stunning and unique in style. Historically, the *Bhils* used to reside in the deep forest and were expert hunters. Today they are settled farmers. The *Kolis* are distinctly identified for their focus on dance.

Agriculture has been practiced in the region from ancient times. As it is blessed with high rainfall, traditionally it was largely a wet crop area, with intense cultivation. Rice was traditionally the main crop followed by *ragi*, pulses, and fodder crops. Productivity was traditionally high. The main traditional horticulture crops were coconut, betel nut, cashew nut, banana, jackfruit, mango, *bhirand* or kokum, pineapple, and a variety of gourds. The Kadambas (1000–1350 CE) and later the Governors of Vijayanagar promoted mango orchards in the region. Although crude methods of mango grafting were known, the Christians helped perfect the art of grafting in Goa.

Agriculture evolved in the region over time, and tribal people accumulated substantial indigenous technological knowledge (Pandit, 2001). For example, the *Warli* community living in the Warli hills of Maharashtra follow complex multiple cropping, making optimum use of the available resources, and mixed cropping (even at the varietal level, the multiline concept), since it was an insurance for specific crop failures, due to pests, drought, and irregular rains and assured the minimum yield. They usually cultivate a few of the more than 10 to 15 traditional varieties (multiline) of paddy, which have different requirement and mature at staggered times and varied in susceptibility to pests and diseases. Under normal conditions, their

main variety gives a good yield; if it does not, the other, hardier varieties lower in yield ensure production of sufficient food (Pereira, 2010).

Technology and products

The agricultural history of the region appears very old, as the region traded in ancient times, in agricultural products like spices, textiles, perfumes, herbs, etc. In fact, the maritime history of the West Coast of India, including the Konkan, predates the birth of Western Civilization. Even before Alexander, there were references to India in Greek works for a flourishing trade with Rome. The Roman writer Pliny speaks of Indian traders carrying away large quantities of gold from Rome, in return for precious stones, skins, textiles, spices, sandalwood, perfumes, herbs, and indigo. The lure of spices attracted traders from the Middle East and Europe to the several trading ports of *Sapt-Konkan*.

To facilitate the high and quality productivity of agricultural produce, the indigenous people evolved effective natural resource management practices. For water management the Lateritic plateaus of the Konkan acted as sponges for water storage. Consequently, numerous small community-managed water harvesting systems evolved, downhill of these plateaus, for centuries. For example, *Daarche Paani* ('water at the doors') is an intricate system of tanks, channels, and falls on a small flat plateau called '*Sadaa*', which supplies water to the village and goes down as a free-flowing stream, to irrigate the plantations of areca nut, pepper, and mangoes. It has evolved

with society in response to the landscape and needs, and to support and help conserve local biodiversity. *Daarche Paani* consists of seven tanks, each built in stone at a different level. The first tank receives continuous freshwater from an underground spring, which is called *Devache Taake* ('Tank of the Gods'). This is generally untouched and is worshiped with locally grown produce every time there is a wedding or a birth in the village. The *Devache Taake* then overflows through a channel to a drinking water tank, from where the women collect water. Washing and bathing near these tanks is not allowed. It is cleaned daily by the first and the last user. Then follows a bigger tank for the cattle, with gently sloping margins. It is interesting to see these margins, which allow small animals as well as birds to use the tank, without the perennial danger of a thirsty one falling in and drowning. Next in the hierarchy are the tanks for cleaning and bathing, which have specially built stone platforms. These tanks converge into a channel, which flows down to irrigate indigenous areca nut and pepper plantations downstream. Further, this small spring eventually joins the river and meets the Vashishthi estuary (Dandekar, 2010). Recognizing the common water scarcity during the summer months, despite heavy rainfall, the traditional farmers have adapted diverse water management techniques to ensure availability of water throughout the year. For example, an underground rainwater harvesting structure constructed in 1710 in Ainy, in Ratnagiri district, construction of ponds for populations, usefulness of tree plantation and use of recharged wells were known to local people from the ancient times (Paranjape *et al.*, 2007).

Most residents of the region are called Konkanis, and they speak an Indo-Aryan language, Konkani, which also uses the written letter in the Devanagari script. The other major ethnic groups of the region are the Tuluvas, living in the coastal districts of Karnataka, Uttara Kannada, Udupi, and Dakshina Kannada, and who speak Kannada.

For conservation of biodiversity, preservation of sizable patches of forests under the reigning deity, in the form of unshaped stone blocks smeared with red paint – *Kalkai* – is common. They are considered amongst the fiercest of deities; breaking even a dead twig in a sacred grove is sure to invite the wrath of the deity. These ‘Sacred Groves’, conserving regional biodiversity in association with a deity, is a unique practice visible in the region (Gadgil and Vartak, 1976). Almost all villages of the Sahyadri and other parts of the region, by tradition, have at least one Sacred Grove ranging from a few to hundreds of acres. These community forests with rich biodiversity have mostly been created at the sites wherefrom originate the streams or rivers, the important source of water for the rural population. This valuable biodiversity is under threat because of encroachment, agriculture, grazing, and developmental activities. Often these groves are connected by seed-dispersing birds (Great Pied and Malabar Pied Hornbill), and are indicators of the type of vegetation that once existed along these hilly terrains. Sacred Groves, as

a common heritage of village/community, also provide vital ecosystem and cultural services to the population for important festivals and social gatherings. Many are still surviving in the Dakshina Kannada and Udupi districts of Karnataka because of certain taboos, religious attachment and strong beliefs supplemented with mystic folklores. They have contributed to the conservation of tropical biological diversity for several species, lost from everywhere. The Sacred Groves are known by different names: in Maharashtra as *Devarai* and *Devarakavu*, and as *Kan* in Uttara Kannada. However, self-centered modern people are ignoring these considerations and have started exploiting and destroying these sacred forests (Chandran, 1997).

In addition to the domestication of the local economically important plants and animal species and adaption of crops from

For water management the Lateritic plateaus of the Konkan acted as sponges for water storage. Consequently, numerous small community-managed water harvesting systems evolved, downhill of these plateaus, for centuries. For example, Daarche Paani (‘water at the doors’) is an intricate system of tanks, channels, and falls on a small flat plateau called ‘Sadaa’, which supplies water to the village and goes down as a free-flowing stream, to irrigate the plantations of areca nut, pepper, and mangoes.

the other parts of the Indian subcontinent, the region has played an important role in the introduction/adaptation of exotic crops from several parts of the world through several ports of the region, such as Mumbai (then Bombay), Dabhol, Goa, Honavar, and Mangalore. Being comparatively near to the Arabian Coast, the region received the earliest travelers. Goa traded with the African coast, Egypt, the Persian Gulf, and Southeast Asia before the medieval period. During the medieval period, after the discovery of the sea route to India in 1498 by Vasco da Gama, the Portuguese in the North Konkan, and the British, Dutch, French, and Spanish in South Konkan intensified trans-oceanic and maritime trade, bringing more exotic crop species to Indian shores (16th century), diversifying and enriching the agricultural crop diversity, and thereby the gene-pools of the region and of the country. The socially dominant Hindu ethos of accepting valuable knowledge and material from any source, ensured adaptation and further dispersal of these exotic crop species to the other parts of the Indian subcontinent. By the early 18th century, the cultivation of tobacco, chili, *chickoo*, guava, *sitaphal*, pineapple, cashew, papaya, and breadfruit became an integral part of the region and South Indian agriculture. The return gesture facilitated the dispersal of Indian crop species to other parts of the world. Facilitation of germplasm exchange has been the greatest contribution of the region to national and global agriculture.

Traditionally, rainfed agriculture was practiced, including the primitive shifting cultivation on the higher slopes, where meager flat land was available for permanent

agriculture. It is known as *Dongarsheti* or *Naglisheti*. The main crops of shifting cultivation are *nacahni* (*Eleusine coracana*), *kang* (*Setaria pallidifusca*), *vari* (*Panicum miliare*) and some traditional vegetables. It was a subsistence activity for the local people who used rich knowledge of their surrounding environment to influence crop yield. However, use of this knowledge and of these practices is on the decline (Godbole and Sarnaik, 2000). Nevertheless, these areas have received minimal impact of modern agriculture and those of high-yielding varieties, with tribal communities preserving local landraces and farmers' varieties.

Rab is an age-old cultivation practice followed in the Konkan region. In this practice, farmers burn the piece of land where a rice nursery is to be raised. Scientifically, rabbing is a sort of partial sterilization of the soil. It improves the physical structure of the soil and increases the availability of nutrients in the soil. The practice is therefore beneficial in raising vigorous seedlings, though it involves wastage of valuable organic matter, which can preferably be used in compost making. *Rab*, also helps control the weeds, provide better germination and healthy seedlings, which help better plant stand and increase the yield on per unit area basis.

Paddy became the main crop of the region occupying 46 per cent of the total cropped area. Traditionally, hundreds of indigenous rice cultivars were cultivated representing significant variability for botanical to agronomic features, engineered by generations of rice farmers and natural

Almost all villages of the Sahyadri and other parts of the region, by tradition, have at least one Sacred Grove ranging from a few to hundreds of acres. These community forests with rich biodiversity have mostly been created at the sites wherefrom originate the streams or rivers, the important source of water for the rural population.

evolution (Fig. 2). Even the smallest tribal farmer grew six to eight traditional varieties, suited to the local microclimates and/or soils. As per the Academy of Development Sciences, Karjat (Raigad District), 300–400 varieties are still grown in the region. Some of the traditional cultivars representing genetic diversity for traits such as nutrition, medicinal properties, pests and diseases resistance are: *Botwel, Mhadi, Walai, Bela, Patni, Bhadas, Kalarata, Bhurarata, Kolamba, Kolpi, Early kolpi, Jiresal, Kala girga, Ghansal, Kothimbari sal (Bodga), Champakali, Krishna sal, Tambada jog, Ambemohar, Kasbai, Thilsa, White luchai, Chinoor, Halga, and Zinia* from the Maharashtra area (Thaware *et al.*, 2011). Kamath (2011) reported a number of traditional cultivars from Goa: *Damgo, Kalo damgo, Babri, Dodig, Kochri, Patni, Korgut, Kalo korgut, Asago, Kendal, Kenal, Vadlo Kenal, Sotti, Giresal, Xitto, Nermar, Mudgo, Shirdi, Belo, Noxvan, Dongri, Valay, Chagar, Kusago, Runga, Odusko, Panyo, Mutalgo, Barik kudi, Dhave, Ek Kadi, Ghansal, Girga, Kalo novan, Kalo Mungo, Karz, Kolyo, Kotmirsal, Masuri, Muno, Ner, Sal, Taysu,*

Shiedi, and Tamde Jyoti. Several of these cultivars have been evolved and conserved with specific traits. For example, *Kolamba* is an early-maturing landrace with greater water-use efficiency, *Patni* and *Dodga* are upland drought tolerant and suitable for coarse sand, and *Panyo* is flood tolerant. *Kalisal* and *Tambsal* are important rice landraces, while *Bhadshi* and *Kuthethivu* are known for high yield, from the Mahad area. *Mazarel* has specifically been selected for *poha* (flat rice) preparation. *Kalbhat* and *Ambemohar* are known for their aroma. *Mhadi, Bela, and Walai* are known for medicinal and nutritional value. Names like *Sal* and *Giresal* indicate Mauryan influence. Kulkarni *et al.* (1998) reported the collection of 25 landraces from the *Mahadeo Koli* tribe, the second largest, including aromatic *Varngal, Rajguda, Kolambi, Tamb, Rajbhog, Halva, and Garva white.* Other common knowledge traditional cultivars from Maharashtra are *Ratnagiri, Ratna, Jaya, Karjat,* etc. Transplanting and dibbling are the popular methods for cultivation with very low use of fertilizers (organic) (Fig. 2). Most traditional cultivars are associated with specific geographical areas and are being grown for specific features like fine grain, scent, and nutritional value. In fact, these cultivars are cultivated

By the early 18th century, the cultivation of tobacco, chili, chickoo, guava, sitaphal, pineapple, cashew, papaya, and breadfruit became an integral part of the region and South Indian agriculture.

Rab is an age-old cultivation practice followed in the Konkan region. In this practice, farmers burn the piece of land where a rice nursery is to be raised. Scientifically, rabbing is a sort of partial sterilization of the soil. It improves the physical structure of the soil and increases the availability of nutrients in the soil. The practice is therefore beneficial in raising vigorous seedlings, though it involves wastage of valuable organic matter, which can preferably be used in compost making.

Rab, also helps control the weeds, provide better germination and healthy seedlings, which help better plant stand and increase the yield on per unit area basis.

and conserved predominantly for the local market, home consumption, and religious rituals. Superiority of some of these traditional cultivars (*Korgut* from Goa) for traits like salt tolerance and cooking quality has been experimentally proved. However, the areas under traditional varieties are going down with the introduction of high-yielding varieties.

The farmers cultivate millets, like *nagli* or *ragi* (*Eleusine coracana*), represented by landraces like *Mutka*, *Kolshi*, *Kaliaguni*, *Gulshi*, *Asani*, and *Argadi* in the Mahad region. They have greater nutritive value and are considered more suitable for people doing hard physical work. Marathe and Bhaskar (2011), while collecting finger millet in Thane, found tribals conserving

11 landraces in the traditional agricultural system. Of these, three have reddish black, two copper red, five light brown, and one white grain. These have drought tolerance, disease resistance, high yield, high protein and amino acid, and low carbohydrate content. Local landraces are also known in *jowar* (*Sorghum bicolor*), like *Dukari* and *Kawali* from Bhor taluka. These strains are cultivated in *kharif*. *Dukari* is cultivated in light soil, has yellow grain and matures in September, while *Kawali* with white grain is cultivated in mixed cropping systems.

The region has contributed significantly to the genetic resources in grain legumes such as *Vigna* and pigeonpea. The region is one of the major centers of diversity of wild *Vigna* species. Of the 24 *Vigna* species reported from India, 12 species occur or are cultivated in the region: *Vigna aconitifolia* (Jacq.) Marechal (moth bean), *V. angularis* (Willd.) Ohwi & Ohashi. (azuki bean), *V. dalzelliana*, *V. khandalensis*, *V. mungo*, *V. mungo* var. *sylvestris*, *V. radiata* var. *setulosa*, *V. sublobata*, *V. trilobata* var. *trilobata*, *V. umbellata*, *Vigna pilosa* Backer ex K. Heyne, *V. unguiculata* ssp. *sesquipedalis*, *V. vexillata* var. *sepiaria* (Dalzell) Babu & S.K. Sharma, and *V. vexillata* var. *stocksii* Baker (Nayar *et al.*, 2009). Characterization and evaluation of the wild *Vigna* species have revealed that the higher yield in *V. radiata* (green gram) is due to the trait donated by the wild *V. sublobata* (Jain and Mehra, 1980). Similarly, in the case of pigeonpea, the landrace *Turk-thogai* (ICP 7217), which has its origin in Karnataka, has been released directly as a variety because of superiority over checks (Remanandan and

Singh, 1997). Additionally, wild species such as *Cajanus lineatus* and *C. sericeus*, identified as sources of resistance to sterility mosaic virus have been collected from the region. *Cajanus sericeus* is also resistant to Phytophthora blight. Significant variability has also been collected in cowpea, lablab bean, horse gram, and moth bean, and a number of varieties have been evolved, such as 'Konkan Sadabahar' and 'Konkan Safed' in cowpea, and 'Konkan Wal-2' in lablab bean. Konkan Sadabahar is a short-duration (55 to 65 days), small-grained, high-yielding (1000 kg ha⁻¹) variety suitable to grow throughout the year. Konkan Safed is bold-grained cowpea with white grains, matures in 75–80 days, and yields about 1200–1300 kg ha⁻¹. Konkan Wal-2 matures in 40–45 days and yields about 1000 kg ha⁻¹, and is drought tolerant and yields well under residual moisture conditions. In chickpea, the small-seeded varieties of the *Warli* tribe are pest resistant (Pereira, 2010).

The Konkan region's tropical climate with high rainfall has supported the cultivation of horticultural crops. To facilitate effective and efficient land use and greater income, a number of mixed cropping systems have evolved in the region, including both rainfed and irrigated, fruit and plantation crops, and cereals, pulses, vegetables, and spices (Fig. 3). For example, papaya is intercropped in sapota orchards; pineapple in coconut orchards; spices such as black pepper, cinnamon, cardamom, and nutmeg with coconut and areca nut, and clove and other spices with coconut. These mixed cropping systems have evolved further genetic diversity in all crops. Among vegetables, significant variability

is recorded in cucurbitaceous crops such as *Cucurbita*, *Cucumis*, and *Luffa*, along with wild relatives of *Cucumis*, *Momordica*, and *Trichosanthes*. In okra, collections have been made with features of *Abelmoschus caillei*, an introduced cultivated species from Africa, suggesting probable outcrossing between *A. esculentus* and *A. caillei*, and its naturalization to the region (Rana *et al.*, 1994). Additionally, *Abelmoschus manihot* ssp. *tetraphyllus* var. *megaspermum* (large seeded) has also been collected from the hill slopes and foothills of the region.

Similarly, the Sahyadri–Deccan hinterland (behind the coast), because of high rainfall and different microclimatic conditions, is suitable for raising quality tropical fruit crops such as mango, jackfruit, pineapple, and sapota, which presents significant variability, particularly in mango. In mango, the region is well known for some high-quality varieties such as *Alphonso* (longer shelf life), *Colaco*, *Mankur*, *Dudhpeda*, *Fernandin*, *Kesar*, *Konkan Ruchi*, *Mankurad*, *Mulgoa*, *Maussarda*, *Pairi* (high pulp content), *Ratna*, *Sindhu*, and *Xavier*, and in jackfruit for varieties such as *Cappco* and *Rassal*. Landraces of jackfruit in national collections from the region include *Koozha*, *Navarikka*, *Varikka*, and *Rudrakha koozha*. Kokum (*Garcinia indica*) growing luxuriously in forest areas, predominantly in the low lying belt, is one of the important minor fruits that have attained commercial value/domestication in recent times. Even in introduced sapota (Spanish introduction from Central America), significant variability has been generated, resulting in the selection of varieties such as *Bhuripatti*, *Dhola Diwani*, *Cricket Ball*,

Jhaumakhia, Kalipatti, Murraba, and Pilipatti.

In coconut, significant variability with superior morphological types, inflorescence, and fruiting characteristics with high yield potential has been recorded. *Benaulim* is a tall variety grown in Goa and coastal Maharashtra. The variety 'Banavali Green Round' named as 'Pratap' was selected from *Benaulim* collections from Ratnagiri and released in 1987 for cultivation in the Konkan Coast region. In areca nut, varieties such as *Shrivardhane* are known from the region. The region is also credited for the introduction of cashew from Brazil, by the Portuguese travelers during the 16th century (1563–1578). It is from the Konkan region (Goa) that the crop spread to other parts of India. In spices, the region exhibits cultivar variability in *Piper nigrum*, ginger, turmeric, and cinnamon. In cinnamon, the variety *Konkan Tej* is a selection from the Ceylon type with superior quality. In turmeric, the variety Krishna was developed through selection in a clone from Tekurpeta collections, with a plummy rhizome and moderate resistance to insect pests and diseases. Even in introduced nutmeg (*Myristica fragrans*), high-yielding *Konkan Sugandha* was selected from a local seedling.

In addition, the farmers of the tribal belts have developed several practices for better land use and to strengthen the subsistence farming. For example, the *Warli* tribe living around the Maharashtra–Gujarat border sow pigeonpea, sorghum, or cowpea in the paddy seedling beds to obtain multiple crops from the same plot without

irrigation. On the borders of the plot, they plant fiber crops like *ambadi* or Deccan hemp (*Hibiscus cannabinus*), *lal ambadi* (*Hibiscus sabdariffa*), or okra. Cucumber and okra are intercropped between rows of maize. *Ambadi* and *Khorasni* (niger) and *udid* (*Vigna mungo*) are cultivated on the borders of fields (Pereira, 2010). The *Warlis* are known for crop rotation, where, after the harvest of quick-maturing paddy, pigeonpea and other crops are planted on the same field to exploit the residual moisture. After their harvest, *harbara* (*Cicer arietinum*), *val* (*Dolichos lablab*), mustard and other crops are grown, which can thrive on the remaining residual moisture. They control pests by planting branches of trees possessing pesticidal properties and for birds to perch, in paddy fields. To control brown spot diseases of paddy, the leaves of *khair* (*Acacia catechu*) are put in the water channels. They cultivate *nagli* (*Eleusine coracana*) and *kodra* (*Paspalum scrobiculatum*) on land on the rocky and infertile hillsides. The tribal farmers of Nandurbar commonly practice sowing five rows of rice alternated with one row of pigeonpea as a drilled rainfed crop, as part of a strategy for effective disease management.

Livestock rearing is an important component of agriculture in the region, which has resulted in the domestication, evolution, and conservation of animal breeds. For example, the *Konkal Kanyal* goat, a meat type breed is adapted to the high rainfall and hot and humid climate of the region. It has typical white bands on a black face, and black ears with white margins (Fig. 4). The body weight of adult bucks and does averages

35 and 30 kg respectively. In May 2012, it has been registered as a distinct breed with the National Bureau of Animal Genetic Resources (www.indianindigenousscattle.blogspot.com/.../nbagr-registered-nine-new-breed).

The Konkan being a coastal region, fishing is another main agriculture activity related with the livelihood of farmers (Fig. 5). Farmers use two methods of fishing, a traditional method called *Dol* and the other using trawlers. In the *Dol* method, hand-woven nets are used for catching the fishes. The nets are placed 18 feet deep in the water with the help of wooden poles and two boats, which help adjust distances of the net. The net is pulled off one hour before the beginning of high tide. The fish that are trapped are then harvested. The fish resources are represented by mullet (*Liza persia*), seahorse (*Hippocampus kuda*), white-spotted-mottled spine-foot (*Siganus canaliculatus*), and ornamental fishes such as angel fish (*Pterophyllum scalare*), gold fish (*Carassius auratus*), rosy barb (*Barbus conchoniis*), and Siamese fighter. The other marine food resources are represented by shrimps such as the banana shrimp, *Penaeus merguensis* and *Metapenaeus affinis*, the two dominant species; the giant freshwater prawn (*Macrobrachium rosenbergii*) and crabs, like mud crab (*Scylla serrata*), green crab (*Scylla tranquebarica*), etc. The latter was a dominant resource in Guhagar, Mandangad, Dapoli, Ratnagiri, and Rajapur Taluka of Ratnagiri District. Additionally, planktonic diatoms (*Chaetoceros* spp.), microalgae (*Isochrysis* spp.), single-cell green algae (*Chlorella* spp.), *Branchinus* spp., *Artemia* spp., etc. are also found

(Marine Biological Research Station, Ratnagiri).

Future perspective

Despite being part of a global biodiversity hotspot and a national micro-center of species endemism, many valleys of the region supporting species-rich forests have been submerged by reservoirs created for hydroelectric dams. Secondary activities, such as road building, encroachment into forests, settlements, fuelwood and non-wood forest product collection have further exacerbated the loss of habitat and biodiversity. The important riparian habitat is the first to be lost. Further, the forest patches are being converted to rubber, areca, and coffee plantations. The grasslands have become highly vulnerable to fire and have retarded growth and regeneration of *shola* forests. These degraded habitats are being colonized by exotic invasive species (*Lantana camera* and *Eupatorium odorata*), restricting the regeneration of native vegetation. Thus, conservation is needed to save the important biodiversity of the region. Additionally, several mountain ranges believed to be islands of species endemism need evaluation and thorough mapping for rare and endangered plant species (Tetali *et al.*, 2000).

The rich climatic conditions of the region are suited for growing horticultural crops, rare medicinal plants, and high-potential export-oriented plantation crops such as tea, coffee, cocoa, pineapple, pepper, etc., reflecting the potential for market-oriented agribusiness. To harness these markets, infrastructure facilities and policies for implementation

of market-oriented agriculture, including dairy, poultry, and fishing need to be evolved. Studies have indicated that in the northern coastal plains, there is ample scope for developing flower cultivation, particularly of jasmine (*mogra*) and crops such as sapota, betel vines, etc.

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