

## Probable Agricultural Biodiversity Heritage Sites in India: XVII. The South-Central Region of Eastern Ghats

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### Abstract

*The central part of the Eastern Ghats, located south of the Krishna River, consisting of the Rayalaseema district of Andhra Pradesh and some bordering southeastern districts of Karnataka, is an arid and semi-arid region, which has been part of the Neolithic-Chalcolithic cultural complex of southern India. Here, agriculture evolved with pastoral farming and dryland agriculture primarily to support pastoral activities, as per the demand of the prevailing ecological conditions. Most people of the region are primarily involved in agriculture-related activities from ancient times. The evidences originating from different sources suggest involvement of the inhabitants of ancient times in the domestication and introduction (adaption) of animals and plants suited to arid and semi-arid conditions. In the process, these inhabitants made significant contributions, in the evolution and conservation of genetic diversity in important groups of animals such as cattle and sheep, and in drought-tolerant crops such as minor millets and pulses. These efforts have been significant particularly in the area of pastoral farming, contributing to world agriculture by sharing valuable cattle germplasm with several parts of the world. For these reasons, the South-Central Region of the Eastern Ghats in India is being proposed as another National Agricultural Biodiversity Heritage Site, based on the indices described for the identification of such sites. The present article discusses the unique features of the region in brief.*

The central part of the Eastern Ghats, south of the Godavari and Krishna rivers, particularly in the southernmost part of the Deccan Plateau, consisting of the southern dry districts of Andhra Pradesh and a few bordering southeastern districts of Karnataka, is an agriculturally important and unique region. Here, agriculture has been practiced from ancient times. The region represents one of the dominant centers of the Deccan Neolithic-Chalcolithic culture, as evidenced by the discovery of the highest

number of archaeological sites. It is the second driest region of India after western Rajasthan, because of the dry ecological conditions created by low rainfall and lack of perennial sources of water. Consequently, the dominant floristic expanses are of savannah grassland and thorny thickets. More than 70 per cent of the human population is involved in agriculture-related activities. The earliest interactions between the human, landscape, and biological diversity resulted in the development of pastoral farming

as the main agricultural activity, which dominated for a long time. Field agriculture evolved later as a supplementary activity to support pastoral farming. Thus, the region specialized in pastoral farming and dryland agriculture as the most important sectors of the economy, and can be credited for the domestication of hardy animals/breeds of cattle and sheep, and drought-resistant crop species of indigenous millets and pulses, generating important diversity, which have been exploited globally both under pastoral farming and field agriculture programs. The archaeological evidences on subsequent evolution of agriculture in the region, suggest adaptation of several crops from other parts of the world, such as pearl millet, sorghum, wheat, etc., and from within the country such as pigeonpea. For these unique contributions, helping the global genetic improvement programs of both animal and plant species, raising the productivity of dairy and meat products on the one hand, and increasing yields of hardy crops on the other, thereby improving the livelihoods of the people in different parts of the world, the region deserves its proposition as another National Agricultural Biodiversity Heritage Site, based on the indices illustrated by Singh and Varaprasad (2008).

### Location and extent

The Eastern Ghats are broadly divided into the Northern-Eastern Ghats and the Southern-Eastern Ghats. Kondapalli (Krishna district), in Andhra Pradesh, is the meeting point between the Northern-Eastern and Southern-Eastern Ghats. Towards the south, the Eastern Ghats run in a westward direction meeting the Western Ghats in the Nilgiris of

Tamil Nadu. The Southern-Eastern Ghats can be further divided into the Central-Eastern Ghats and South-Eastern Ghats. The former mainly constitutes the southern parts of Andhra Pradesh comprising areas south of the rivers Godavari and Krishna, and includes the Nallamalai-Palakonda ranges, Seshachalam hills, Rayalaseema, Tirupati hills and adjacent semi-arid districts of Karnataka. Geographically, it extends into the Eastern Ghats, forming a chain of discontinuous range of hills with good vegetation, and the Deccan Plateau consisting of agricultural lands, scrub, and deciduous forests. Agroecologically it represents the semi-arid zone, comprising a part of the Deccan Plateau that includes the Rayalaseema region and parts of Telangana from Andhra Pradesh, and the Raichur and Bellary districts of Karnataka. Administratively, it consists of the districts of Chittoor, Anantapur, Kadapa, Kurnool of the Rayalaseema region (lying between 12°41' and 16°21' N, and between 17°45' and 81°1'E), extending into Nellore and Prakasam districts (excluding the coastal plains) of Andhra Pradesh, and the districts of Bellary, Raichur, and Kolar of Karnataka, extending into small parts of the uplands and areas of Nilgiris in Tamil Nadu (Fig. 1). The region on the north is bounded by the Telangana region and coastal plain of Andhra Pradesh, Karnataka in the west, coastal plain and Bay of Bengal in the east, and extremes of the South-Eastern Ghats falling in Tamil Nadu in the south.

### Landscape

The major landscape of the area is moderate to gentle sloping, consisting of lush or dry plains with numerous hilly areas,



**Figure 1. Location and extent of the South-Central Region of the Eastern Ghats demarcated by dotted and solid lines.**

intercepted by a few rivers and river-valleys. However, most of the regions, particularly the Rayalaseema area, are undulating, dotted with ridges and clusters of rocky hills. The mountain ranges are comparatively low without thick forests. The hilly tracts cover areas between the river Krishna and Tamil Nadu, including the districts of Krishna (Kondapalli range), Kurnool (Nallamalai range), Kadapa (Yerramala, Palakonda ranges), Nellore (Velikonda range), and Chittoor and Kadapa (Seshachalam-Lankamala-Nagari-

Kambakkam ranges) of Andhra Pradesh, representing the Middle (Central) Eastern Ghats (Pullaiah and Rao, 2002). North of the Palar River of this region, the central portion of the Eastern Ghats consists of two parallel ranges running approximately north-south; the lower Velikonda range lying in the east, and the higher Palakonda-Lankamala-Nallamalai ranges lying in the west. The Palar River cuts through these ranges. The Velikonda range eventually descends to the coastal plains in northern Nellore district, while the Nallamalai range continues up to

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the River Krishna. The southern low hilly area runs in a west-southwest direction and meets the high mountain ranges of the Western Ghats in the Nilgiri belt, representing the Southern-Eastern Ghats, covering the Tamil Nadu districts of the Eastern Ghats.

### Agroclimate

The climate of the region is characterized by hot and dry summers, and a very mild winter season. Lying almost in the southern part of the peninsula, the area comes under the influence of both monsoons – southwest and northwest – but does not get the full force of either. Hence, the frequent failure of rains causes failure of crops, causing scarcity of food, fodder, and employment. Because of the erratic rainfall, the annual mean ranges from 400 to 1,000 mm. It covers about 40 per cent of the potential evapotranspiration (PET), resulting in a gross water deficit of 700–800 mm. The South-Central Eastern Ghats and the southern Deccan Plateau receive very little rainfall during winter. The region experiences severe drought nearly throughout the year. The cultivation period with moisture availability extends

between 90 and 150 days (Sehgal *et al.*, 1992), but in some years the length of the growing period may extend between 120 and 150 days in a year. The period from February to May is the driest period of the year in the region. The temperatures range between 25°C and 29°C, and they are higher in the *kharif* (rainy) season than in the *rabi* (postrainy) season. Physiographically, the region is a hot semi-arid ecoregion with dominant red loamy soil and clayey black soils. The red soils are of the *Kadiri* series, non-calcareous and slightly acidic in nature. The deep clayey black soils represented by Raichur series are slightly alkaline and calcareous in nature.

The watershed of the Penner (Penna or Penneru) River and its tributaries covers part of the southern Deccan plateau, including most of the Rayalaseema region of Andhra Pradesh, and part of Karnataka. Therefore, the paucity of perennial rivers, low rainfall, and an enervating climate have hampered the progress of agriculture and development in some of the areas of the region, particularly Rayalaseema, which is often referred to as the Famine Zone of South India.

### Floristic diversity

The region is bestowed with unique biodiversity consisting of the natural vegetation represented by a large area of tropical dry deciduous forests, mixed dry deciduous forests, and tropical thorn forests (Champion and Seth, 1968) of the southern Deccan plateau, and dry districts on the leeward side of the southern Western Ghats mountain ranges. These forests extend across

southern Andhra Pradesh and the uplands of southeastern Karnataka. The dry deciduous forests of the region are flanked by the moist deciduous forests along the lower elevations, which receive the southwest monsoon, and by the thorn scrub in regions that receive the northeast monsoon.

The Tropical Dry Deciduous Forests common to the Eastern Ghats are divided into Teak-bearing and Non-Teak-bearing forests. The Seshachalam hill ranges of the Central-Eastern Ghats and North Arcot of the Southern-Eastern Ghats contain Non-Teak-bearing forests. These forests have the important and very valuable endemic tree, the *raktachandana* or red sanders (*Pterocarpus santalinus* L.f.) and also the dry type of *sal* (*Shorea tumbuggaia* Roxb.), besides the *Syzygium alternifolium* (Wight) Walp., and *Boswellia ovalifoliolata* Bal & Henry, prominent in some areas, mixed with other species like *Terminalia pallida* Linn., *Shorea roxburghii* Don., *Emblica officinalis* Gaertn. (syn. *Phyllanthus emblica* Linn.), *Anogeissus latifolia* (Roxb.) Wall. ex. Bedd, *Terminalia paniculata* Roxb., *T. alata* Herb. Madr. ex Wall., *Chloroxylon swietenia* DC., *Dolichandrone arcuata* (Wight) Clarke, *Wrightia tinctoria* (Roxb.) R.Br., *Vitex altissima* L.f., etc.

The Mixed Dry Deciduous Forests found in the drier areas of the Eastern Ghats are dominated by tree elements, like *Anogeissus latifolia*, *Chloroxylon swietenia*, *Diospyros melanoxylon* Roxb., *Gardenia gummifera* Linn.f., *Albizia odoratissima* Benth. (syn. *Mimosa odoratissima* Roxb.), *Hardwickia binata* Roxb., *Pterospermum xylocarpum* (Gaertn.) Oken., *Helicteres*

*isora* L., *Xeromphis spinosa* (Thunb.) Keay, *Flacourtia ramontchi* L'Herit., etc. The scrub or thorn forests are dominated by thorny species of *Acacia* Mill. spp., *Capparis sepiaria* (L.) R.Br., *Ziziphus mauritiana* Lam. (syn. *Z. jujuba* Mill.), *Z. oenoplia* Mill., *Z. xylopyra* (Retz.) Willd., *Euphorbia antiquorum* L., *E. tirucalli* L., *Flacourtia sepiaria* Roxb., *Xeromphis spinosa* and also associated with non-thorny drought-resistant species like *Dolichandrone falcata* (Wall. ex DC.) Seem., *Wrightia tinctoria*, *Dodonaea viscosa* (L.) Jacq., *Cassia fistula* Linn., etc. (Sandhyarani *et al.*, 2007).

The Nallamalai-Cuddapah range is floristically rich with marked presence of dry type of vegetation (Ellis, 1987). The hill ranges of Velikonda, Seshachalam, Palakonda, Lankamala, and Nallamalai have an evergreen scrub type of vegetation in the lower plains or ravines, and a deciduous type on the hills and in the relatively wet valleys. *Acacia farnesiana* (L.) Willd., *Azadirachta indica* A.Juss., *Balanites aegyptiaca* (L.) Del., *Boswellia ovalifoliolata*, *Cassia auriculata* L. [syn. *Senna auriculata* (L.) Roxb.], *Diospyros chloroxylon* Roxb., *D. melanoxylon*, *Euphorbia antiquorum*, *Gardenia latifolia*

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Schlecht. ex Hook.f., *Hardwickia binata*, *Manilkara hexandra* (Roxb.) Dubard, *Morinda citrifolia* L., *Premna tomentosa* Miq. ex C.B. Clarke, *Prosopis spicigera* L., *Sapindus emarginatus* Hort. Algo., *Soyimida febrifuga* (Roxb.) A. Juss., *Syzygium alternifolium*, *Terminalia chebula* Willd. ex Flem., *T. pallida*, *Ventilago madraspatana* Gaertn., *Ziziphus mauritiana*, and *Z. vulgaris* Lam. are some of the major components of the vegetation. The Tirupati hills are floristically rich with *Ceiba pentandra* (L.) Gaertn., *Pterocarpus santalinus*, *Pterospermum heyneanum* Wall., *Grewia tiliaefolia* Vahl., *Erythroxylum monogynum* Roxb., and *Aglaia roxburghiana* (W.&A.) Miq. The leguminous endemic species occupy the understory of the deciduous forests and scrub jungles with *Crotalaria shevaroyensis* Gamble (syn. *Crotalaria longipes* Wight & Arn.), *C. perfoliata* L., *Indigofera barberi* Gamble, *Rhynchosia beddomei* Baker, *R. filipes* Benth, etc.

The economically valuable endemic plant species of the region, *Pterocarpus santalinus* (the sacred *raktachandana*) and *Cycas beddomei* W.T.T. Dyer are distributed in the Kadapa and Tirupati hills. They have become rare due to overexploitation for their professed medicinal and cosmetic

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properties. The other endemic species *Boswellia ovalifoliolata* and *Pimpinella tirupatiensis* Bal. & Subr. are adapted to specialized ecological conditions. The wide range of topography and other physical features, and the geological factors of *Kadapa* formation and soil types with red and calcareous shales support a number of endemic species, including edaphic ones in the vegetation.

Most of the dry tropical forests of the region have now disappeared due to clearance by grazing and overharvesting of the forests for timber and firewood, and are replaced by thorny shrub lands. The region is also endowed with rich fauna, livestock, and land resources.

### **Agriculture and agrobiodiversity**

The pastoral farming and rainfed agriculture are the traditional farming practices in the region. The latter may include fallowing the land in the rainy season and growing of a crop in the postrainy season on residual/conserved moisture. It is observed that the farmers of the region follow predominantly dryland-based agriculture, dependent on low rainfall. For these reasons, in the dry districts of Anantapur and Kadapa, *podu* or shifting cultivation and pastoral farming

are still common. Because of low rainfall, traditionally, millets locally known as *satyam pantalu* (crops of truth) were very common among poor and marginal farmers, as these crops grow on practically no inputs and even on highly infertile soil. In fact, in Andhra Pradesh, except for coastal areas, most of the regions grew millets [pearl millet (*bajra*), finger millet (*ragi*), other small millets], and other traditional crops like pulses. However, after the Green Revolution, most farmers gave up millets farming and took to cultivation of hybrids and cash crops, despite the millets being well-known for suitability to semi-arid agroecology and high nutritional value and other benefits, like fodder to support pastoral farming. Thus, the area under millets cultivation has declined over the last five decades, especially after the Green Revolution. Between 1966 and 2006, more than 44 per cent of millets cultivation areas have been occupied by other crops, primarily cash crops. Government policies towards millets have also led to their decline causing severe genetic erosion. The other major crops grown are rice, sorghum (*jowar*), cotton, sugarcane, pulses (beans, peas, lentil, and horse gram), groundnut, bananas, tobacco, etc.

The major *kharif* crops are sorghum, cotton, pigeonpea, and groundnut, while in the *rabi* season, sorghum, sunflower and other oilseeds are grown on residual soil moisture. Rice is cultivated under irrigated conditions. The important crops cultivated in the semi-arid southern Andhra Pradesh are millets, pulses, and oilseeds in the *kharif* season and sorghum, cotton, and oilseeds in the *rabi* season. Groundnut is cultivated in southern Andhra Pradesh and adjoining northeastern

Tamil Nadu both under irrigated and non-irrigated conditions.

Diverse cropping systems and pattern are followed in the Anantapur (dry) region. The crops that are cultivated are early-maturing sorghum varieties, pigeonpea, castor, mesta, etc. If the rains arrive late, then pearl millet, foxtail millet, and groundnut are sown (Rathore and Gupta, 1991). In the Kolar semi-arid region, *kharif* crops like maize, pigeonpea, and *ragi* are grown, while in the eastern zone of the region, sorghum, pearl millet, groundnut, and cowpea are grown. Some of the common cropping patterns are rice–sesame, rice–groundnut, rice–sunflower, sesame–finger millet, mung bean/black gram–groundnut, finger millet–rice–groundnut, rice–rice–groundnut, rice–rice–sesame–groundnut, and rice–rice–sesame. The following combinations of crops are practiced under the mixed cropping systems: castor+ginger/turmeric; castor+sesame; and castor+sesame/pigeonpea+groundnut.

Under the evolutionary history of agriculture of the region, pastoral farming occupied prime position. One of the reasons for this was that the region was endowed with rich livestock diversity and land resources with savannah grassland and thorny thickets for their feed. Livestock rearing still occupies an important status among resource-poor farmers. A survey has shown that 70 per cent of the small and marginal farmers and agricultural laborers depend upon livestock rearing. The requirement of fodder for livestock is met mostly from the straw and/or residues of various food crops (60%), and in a limited way from the fodder crops and the ever-diminishing pasturelands.

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### **Representative crop species in various crop groups**

#### **Cereals, pseudocereals, and millets.**

Barnyard millet [*Echinochloa crus-galli* (L.) P. Beauv.], *Dactyloctenium aegyptium* (L.) Beauv., *Digitaria tomentosa* (Koen. ex Rottl.) Henr., finger millet (*Eleusine coracana* Gaertn.), korralu (Telugu) or navane (Kannada) or foxtail millet [*Setaria italica* (L.) Beauv.; *Setaria verticillata* L.], kodo millet (*Paspalum scrobiculatum* L.), maize (*Zea mays* L.), millet-grasses [*Brachiaria ramosa* (L.) Stapf], pearl millet [*Pennisetum glaucum* (L.) R.Br.], proso millet (*Panicum miliaecum* L.), rice (*Oryza sativa* L.), sanwa (*Echinochloa frumentacea* Link.; syn. *Panicum frumentaceum* Roxb.), sorghum [*Sorghum bicolor* (L.) Moench], *thipa ragi* (*Eleusine indica* Steud.), *vedalu* (*Echinochloa colonum* L.), and wheat (*Triticum aestivum* L., *T. dicoccum* Schubl.). Additionally, wild *Panicum* spp. are also cooked as rice.

**Grain legumes and oilseeds.** Chickpea (*Cicer arietinum* L.), green gram [mung bean; *Vigna radiata* (L.) R. Wilczek], groundnut (*Arachis hypogaea* L.), horse gram [*Macrotyloma uniflorum* (Lamk.) Verdc.], hyacinth bean [*Lablab purpureus* (L.) Sweet; syn. *Dolichos lablab* L.], mustard (*Brassica*

*campestris* L.), niger [*Guizotia abyssinica* (L.f.) Cass.], pigeonpea [*Cajanus cajan* (L.) Millsp.], purple bean [*Macroptilium atropurpureum* (DC.) Urb.], safflower (*Carthamus tinctorius* L.), sesame (*Sesamum indicum* L.), sunflower (*Helianthus annuus* L.) and non-edible oilseeds – castor (*Ricinus communis* L.), physic nut (*Jatropha curcas* L., *J. gossypifolia* L.) (a recent introduction), sweet pea (*Lathyrus odoratus* L.), and lentil (*Lens culinaris* Medik.).

**Fodder and fiber crops.** Cotton (*Gossypium hirsutum* L., *G. arboreum* L.), *Decaschistia cuddapahensis* Paul and Nayar, *D. rufa* Craib, kenaf (*Hibiscus cannabinus* L.), roselle (*Hibiscus sabdariffa* L.), sunn hemp (*Crotalaria juncea* L.), and fodder – *mushel* (*Iseilema laxum* Hack.) and velvet bean [*Mucuna pruriens* (L.) DC. var. *pruriens*]. Additionally, forage types of sorghum, pearl millet, and minor millets are cultivated.

**Vegetables.** *Bhindi* or okra [*Abelmoschus esculentus* (L.) Moench], bitter melon (*Momordica balsamina* L., *M. charantia* L.), bottle gourd [*Lagenaria siceraria* (Molina) Standley], brinjal (*Solanum melongena* L.), cucumber (*Cucumis sativus* L.), *kachra* (*Cucumis melo* var. *agrestis* Naud.), kudzu vine [*Pueraria tuberosa* (Roxb. ex Willd.) DC], muskmelon (*Cucumis melo* L.), pumpkin (*Cucurbita pepo* L.), and sponge gourd (*Luffa cylindrica* Roxb.).

**Leafy vegetables.** *Adavi gogu* (*Hibiscus aculeatus* Walt.) (leaves as pot herb), amaranthus (*Amaranthus spinosus* L., *A. tenuifolius* Willd., *A. viridis* L., *A. dubius* Mart. ex Thell.), *ambary* (*Hibiscus cannabinus*) (leaves pickled), *Corchorus*



*aestuans* L. (tender leaves), and *Digera muricata* (L.) Mart. (pot herb).

**Bulb, root, and tubers.** Elephant-foot yam [*Amorphophallus paeonifolius* (Dennst.) Nicolson], mango ginger (*Curcuma amada* Roxb.), onion (*Allium cepa* L.), and potato yam (*Dioscorea bulbifera* L.).

**Fruits.** *Aonla* (*Emblica officinalis*), *bael* [*Aegle marmelos* (L.) Correa ex Roxb.], clove tree [*Syzygium aromaticum* (L.) Merr. & L.M. Perry], custard apple *Annona squamosa* L.), country date palm [*Phoenix sylvestris* (L.) Roxb.], date palm [*P. robusta* (Becc.) Hook. f.], grapes (*Vitis vinifera* L.), *jamun* [*Syzygium cumini* (L.) Skeels], *kaith* or wood apple (*Limonia acidissima* L.), *karonda* (*Carissa carandas* Lour.), *khonda mavu* (*Commiphora caudata* Engl.; syn. *C. wightii* Arn.), lime [*Citrus aurantifolia* (Christm.) Sw.; syn. *C. medica* L.], mango (*Mangifera indica* L.), pomelo [*Citrus maxima* (Burm.) Merr.], rose apple [*Syzygium jambos* (L.) Alston], toddy palm or palmyra (*Borassus flabellifer* L.), watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai], and *Ziziphus mauritiana*.

**Spices.** Chili (*Capsicum annuum* L.), coriander (*Coriandrum sativum* L.), curry leaf [*Murraya koenigii* (L.) Spreng.], ginger (*Zingiber officinale* Rosc.), and turmeric (*Curcuma domestica* Valet.; syn. *C. longa* L.).

**Ornamentals.** Some naturalized ornamental species are *Bauhinia purpurea* Linn., *bela* or jasmine (*Jasminum* L. spp.), bluebell barleria (*Barleria cristata* Linn.), *Crossandra infundibuliformis* (L.) Nees,

*Gomphrena globosa* L., and scarlet ixora (*Ixora coccinea* Linn.).

**Other economic plants.** Bamboo [*Bambusa arundinacea* (Ritz.) Roxb.; *Dendrocalamus strictus* (Roxb.) Nees.], sugarcane (*Saccharum officinarum* L.), and tobacco (*Nicotiana tabacum* L.).

**Medicinal plants.** Some of the common medicinal plants known from the region are *baheda* [*Terminalia bellirica* (Gaertn.) Roxb.], *Centella asiatica* (L.) Urban, *Costus speciosus* Koen ex Retz.) Sm., *Cassia fistula*, *giloe* [*Tinospora cordifolia* (Willd.) Hook. f. & Thomson], *Gloriosa superba* L., *harada* (*Terminalia chebula*), *kalmegh* [*Andrographis paniculata* (Burm. f.) Wall.], noni (*Morinda citrifolia*), *Phyllanthus amarus* Schum., *Piper longum* L., *Plumbago zeylanica* L., *Strychnos nux-vomica* L., and *Tacca leontopetaloides* (L.) Kuntze. Raju and Ramana (2011) have described the use of *Decalepis hamiltonii* Wight & Arn., as a health drink. In addition, Rao *et al.* (2006) have listed a total 240 plant species of medicinal significance with enumeration on their uses from the Rayalaseema area. Reddy *et al.* (2009) have reported ethnomedicinal uses of 48 plant species, belonging to 44 genera and 30 families, used to cure 32 types of ailments from the Seshachalam hill ranges of Kadapa district alone.

**Timber.** Dry type *sal* (*Shorea tumbergaia*), *neem* (*Azadirachta indica*), *raktachandana* – the sacred wood (*Pterocarpus santalinus*), *teak* (*Tectona grandis*), and *Terminalia tomentosa*.

**Multipurpose and aromatic plants.** Lemon grass [*Cymbopogon flexuosus* (Steud.)

Wats., *Cymbopogon martinii* (Roxb.) Wats.] and *Hildegardia populifolia* (Roxb.) Schott & Endl. (medicinal and fiber).

**Gum- and resin-yielding plants.** The forests of the region yield a large variety of non-timber forest produce, including *sal* seeds (from which an edible oil is extracted), *tendu* leaves (for rolling local cigarettes), gum *karaya* (a type of emulsifier), bamboo, etc. As the tribals are interconnected with the habits of local biodiversity and natural resources, they gather root and tubers for food, medicinal herbs for health care, animals for food, and mineral-based products for income.

**Wild relatives of crop species.** Arora and Nayar (1984) recorded *Abelmoschus ficulneus* Wight & Arn., *Amorphophallus campanulatus* (Roxb.) Bl. ex Decne, *Boehmeria platyphylla* D. Don., *Canavalia stcockii* Dalz., *Coleus forskohlii* (Willd.) Briq., *Corchorus antichorus* Raeuch, *Grewia tenax* Forsk., *G. villosa*, *Luffa umbellata* M. (Klein) Roem, *Malva rotundifolia* Linn., *M. sylvestris* Linn., *Momordica subangulata* Blume, *Panicum hypheron* Schult. and *P. lippothrix* K. Schum (grain cooked like rice), *Sesamum laciniatum*

Klein, *Vigna trilobata* (Linn.) Verdc., and *V. umbellata* (Thunb.) Ohwi & H. Ohashi from the region. However, since then many more wild relatives of crop species, such as *Cajanus scarabaeoides* (L.) Thouars, *Carissa inermis* Vahl, *Crotalaria shevaroyensis*, *C. perfoliata*, *Cucumis melo* var. *agrestis*, *Cymbopogon* L. spp., *Dioscorea intermedia* Thwaites, *D. pentaphylla* L., *D. wallichii* Hook.f., *D. wightii* Hook.f., *Eleusine indica* (L.) Gaertn., *Indigofera barberi*, *Jasminum angustifolium* Wall., *J. auriculatum* Vahl, *J. scandens* Griff., *Momordica tuberosa* Cogn., *Phoenix pusilla* Gaertn., *Phyllanthus fischeri* (Gamble) J.L.Ellis, *Sesamum alatum* Thonn., *S. prostratum* Retz., *Solanum erianthum* D. Don, *S. nigrum* L., *S. surattense* Burm.f., *Sorghum halepense* Pers., *Syzygium alternifolium*, *S. zeylanicum* (L.) DC., *Trigonella occulta* Delile, *Vitis adnata* (Roxb.) Wall., *V. linnaei* (syn. *Cissus vitiginea* L.), *V. pallida* Wight & Arn. (syn. *Cissus pallida* Wight & Arn.), and *V. woodrowii* Stapf. have also been reported from the region.

**Endemic species.** As per Nayar (1996) and Reddy *et al.* (2009), *Albizia sikharamensis*, *Andrographis nallamalayana* Ellis, *Boswellia ovalifoliolata*, *Canavalia stcockii* Sm., *Crotalaria madurensis* R. Wight, *C. longipes*, *C. madurensis* var. *kurnoolia* Ellis, *C. perfoliata*, *C. sandoorensis* Gamble, *C. shevaroyensi*, *Cycas beddomei*, *Decaschistia cuddapahensis*, *D. rufa*, *Eriolaena lushingtonii* Dunn, *Hildegardia populifolia* (Roxb.) Schott & Endl., *Indigofera barberi*, *I. mysorensis* DC., *Luffa acutangula* var. *amara* Roxb., *Oryza officinalis* ssp. *malampuzhaensis* Krish. & Chand., *Parahyparhenia bellariensis*, *Pimpinella tirupatiensis* Balakr. and

*Under the evolutionary history of agriculture of the region, pastoral farming occupied prime position. One of the reasons for this was that the region was endowed with rich livestock diversity and land resources with savannah grassland and thorny thickets for their feed. Livestock rearing still occupies an important status among resource-poor farmers.*

Subram., *Pterocarpus santalinus*, *Rhyncosia beddomei*, *Rhyncosia filipes*, *Shorea tumbuggaia*, *Syzygium alternifolium*, and *Terminalia pallida*. Economically important representative endemic species of the region are presented in Table 1.

**Threatened species.** *Boswellia ovalifoliolata*, an endemic and keystone species, is threatened and endangered due to the vivid geographical conditions and climatic change (Savithramma *et al.*, 2010). Other endemic species commonly recorded threatened are *Acacia campbellii* Arn., *Aegle marmelos*

**Table 1. Representative plant species endemic to the South-Central Eastern Ghats.**

Species	Family	Habit	Distribution	Use
<i>Andrographis nallamalayana</i>	Acanthaceae	Herb	Tirupati, Kadapa, Nallamalai hills	Medicine
<i>Boswellia ovalifoliolata</i>	Burseraceae	Tree	Southern-Eastern Ghats	Wood and paper
<i>Crotalaria madurensis</i> var. <i>kurnoolia</i>	Fabaceae	Shrub	Southern-Eastern Ghats	Genetic resource
<i>Crotalaria paniculata</i> var. <i>nagarjunecondensis</i>	Fabaceae	Undershrub	Southern-Eastern Ghats	Genetic resource
<i>Cycas beddomei</i>	Cycadaceae	Shrub	Southern-Eastern Ghats	Ornamental, cosmetic
<i>Decaschistia cuddapahensis</i>	Malvaceae	Shrub	Tirupati, Kadapa, Nallamalai, and Seshachalam hills	Leaves as vegetable
<i>Indigofera barberi</i>	Fabaceae	Shrub	Tirupati, Kadapa, Nallamalai	Genetic resource
<i>Luffa acutangula</i> var. <i>amara</i>	Cucurbitaceae	Climber	Southern-Eastern Ghats	Genetic resource
<i>Oryza officinalis</i> ssp. <i>malampuzhaensis</i>	Poaceae	Perennial herb	Southern-Eastern Ghats	Genetic resource
<i>Pimpinella tirupatiensis</i>	Apiaceae	Herb	Tirupati, Kadapa, Nallamalai	Medicinal (tuberous roots)
<i>Pterocarpus santalinus</i>	Fabaceae	Tree	Southern-Eastern Ghats	Wood for building and agricultural implements
<i>Shorea tumbuggaia</i>	Dipterocarpaceae	Tree	Tirupati, Kadapa, Nallamalai	Timber, medicinal

Source: Nayar (1996).

var. *mahurensis* Zate, *Albizia thompsoni*, *Asparagus rottleri* Baker, *Ceropegia spiralis* Wight., *Crotalaria paniculata* Willd. var. *nagerjunekondensis* Thoth, *C. willdenowiana* ssp. *glabrifoliolata* Ellis, *Cycas beddomei*, *Indigofera constricta* (Thw.) Trimen, *Psilotum nudum* L., *Pterocarpus santalinus*, *Rhynchosia beddomei*, *Shorea talura* Roxb., *S. tumbuggaia*, *Syzygium alternifolium*, and *Terminalia pallida* (Nayar, 1996). Recently, Rao et al. (2011) have reported *Hildegardia populifolia* (Roxb.) Schott & Endl. to be under threat. Reddy and Reddy (2008), based on IUCN Red List categories - 2000, assessed 50 prioritized medicinal plant species found in Andhra Pradesh, of which 39 are under threat. Selected threatened species from the region are listed in Table 2.

### Associated culture and tribes

The origin of agriculture in South India is obscure. However, the various evidences generated in the recent past suggest it to be quite ancient, represented by the southern Neolithic cultural complex. During the last 150 years, more than 800 Neolithic sites have been discovered from southern states, with Andhra Pradesh (Rayalaseema) representing the highest number (200). In fact the Neolithic-Chalcolithic culture of Andhra Pradesh forms part of the Deccan Neolithic-Chalcolithic culture along with Karnataka and Maharashtra, overlapping with the Iron Age by c. 1000 BCE. The Iron Age of Andhra is characterized by elaborate burials called Megaliths. Some scholars associate these Megaliths with pastoral nomadism. The Megalithic period in Andhra approximately covers the later part of the second millennium BCE

to the beginning of the Christian era. The distinctive feature of the south-central region cultural sites are the ash mounds, consisting of large, heaped accumulations of cattle dung, which have been episodically burnt, corroborating the presence of pastoralist camps (Allchin, 1963; Paddayya 1973, 1992) in ancient times. The evidences from the animal and plant remains found from the excavated sites suggest the dominant role of domesticated cattle, with supporting crops such as millets, beans, the common pea, horse gram, black gram, and rice. During this period, the main source of food and stay of the economy was probably cattle pastoral farming followed by millets farming (Murty, 2003). A number of excavated sites from the region also reflected animal husbandry as the chief activity of human settlements with the plant remains represented inadequately. However, in the excavation at Veerapuram in Kurnool district of the region, the food grains of *Oryza sativa*, *Hordeum vulgare*, *Paspalum scrobiculatum*, *Pisum arvense*, *Dolichos biflorus*, *Lablab purpureus*, and *Vigna mungo* and fruit remains of *Ziziphus* sp. and *Terminalia bellirica* have been found, like other sites of southern India, suggesting that the region had similar status in agricultural development as that of the neighboring region of Maharashtra and Karnataka (Kajale, 1984). At Maski, in Raichur, *Acacia* and *Chloroxylon swietenia* were exploited for firewood from the early first millennium BCE to first century CE.

Recent, preliminary archaeobotanical results (Fuller *et al.*, 2004) have produced further evidences to suggest that, with regard to plants, the earliest agriculture in South India (predominantly including parts of this

**Table 2. Representative plant species under threat in the South-Central Eastern Ghats.**

Species	Family	Habit	Threat status <sup>1</sup>	Use
<i>Acacia campbellii</i> <sup>2</sup>	Fabaceae	Tree	VU	Timber
<i>Aegle marmelos</i> var. <i>mahurensis</i>	Rutaceae	Tree	R	Fruit and medicinal
<i>Albizia thompsonii</i> <sup>2</sup>	Fabaceae	Tree	VU	Wood
<i>Asparagus rottleri</i> <sup>2</sup>	Liliaceae	Sub-shrub	DD	Medicinal
<i>Boswellia ovalifoliolata</i> <sup>2</sup>	Burseraceae	Tree	EN	Wood and paper
<i>Ceropegia spiralis</i>	Asclepiadaceae	Twiner	VU	Medicinal (ceropegine)
<i>Crotalaria wilddenowiana</i> var. <i>galbrifoliata</i>	Fabaceae	Shrub	R	Genetic resource
<i>Cycas beddomei</i> <sup>2</sup>	Cycadaceae	Small tree	CR	Ornamental, cosmetic
<i>Erythrina variegata</i> forma <i>mysorensis</i>	Fabaceae	Tree	DD	Medicinal (root extract)
<i>Hildegardia populifolia</i> <sup>2</sup>	Sterculiaceae	Tree	VU	Fiber
<i>Indigofera constricta</i> <sup>2</sup>	Fabaceae	Shrub	R	Genetic resource
<i>Pimpinella tirupatiensis</i> <sup>2</sup>	Apiaceae	Herb	EN	Medicinal (tuberous roots)
<i>Pterocarpus santalinus</i>	Fabaceae	Tree	EN	Sacred wood
<i>Rhynchosia beddomei</i> <sup>2</sup>	Leguminosae	Shrub	VU	Medicinal, genetic resource
<i>Shorea tumbuggaia</i>	Dipterocarpaceae	Tree	EN	Timber, medicinal
<i>Syzygium alternifolium</i>	Myrtaceae	Tree	EN	Fruits, medicinal
<i>Terminalia pallida</i>	Combretaceae	Tree	EN	Medicinal

1. CR = Critically endangered; EN = Endangered; DD = Data deficient; R = Rare; VU = Vulnerable.

2. Listed by the Ministry of Environment and Forests (Source: Reddy and Reddy, 2008).

region) dates back to the third millennium BCE. It was based on plants domesticated in the region, which were subsequently enriched with introduction and adaption of additional crops from other regions into the subsistence system from the late third millennium BCE through the second

millennium BCE. This study has evidences for staple crops of two pulses (*Vigna radiata* and *Macrotyloma uniflorum*) and two millet-grasses (*Brachiaria ramosa* and *Setaria verticillata*), which were indigenous to the Indian peninsula and might have been domesticated in this region. Wheat



(*Triticum diococcum*, *T. durum*, or *T. aestivum*) and barley (*Hordeum vulgare*), and a few crops that originated in Africa, including hyacinth bean (*Lablab purpureus*), pearl millet (*Pennisetum glaucum*), and finger millet (*Eleusine coracana*) present at some of these sites, suggest limited cultivation of these introduced crops in the later phase of agricultural evolution. In addition, there is evidence for the cultivation of cotton (*Gossypium* sp.) and linseed (*Linum* sp.), as well as of *Ziziphus* and two cucurbits, *Cucumis* cf. *prophetarum* L. and cf. *Luffa cylindrica* (L.) Roem., from the gathered fruits. In historical literature, Andhra Pradesh's earliest appearance is found in Aitareya Brahmana (800 BCE) as *Dakshina Padh*, a gateway to South India.

Though most of the people of the region are believed to be of Dravidian origin, but some theories suggest that they were Aryans by origin who moved south of the Vindhya, and eventually mixed with the local non-Aryans. The hilly areas of the region are inhabited by large tribal communities. The well known tribes of the region are the *Gonds*, the *Sarvas*, the *Bagatas*, the *Mandulas*, the *Yenadis*, the *Chenchus*, the *Gadabas*, the *Yerukulas*, the *Sugalis*, and the *Mathuris*. The *Banjaras* (or gypsies) appears to be a later entry. The other major tribes are *Jatapus*, *Khonds* (*Samantas*), *Kondadoras*, *Konda Kammaras*, *Konda Reddis*, *Koyas*, *Nuka Doras* (*Muka Doras*), *Savaras*, and *Valmikis*. Some Negritos tribes like *Irulas*, *Kodars*, *Paniyans*, and *Kurumbas* are also found in patches. Most tribes are professionally food-gatherers, hunters, nomads, and small farmers.

Over time, some of the crops have become an integral part of the local culture; for example, on the day of '*Peddala amavasya*', a day for worshiping ancestors, foxtail millet (*Setaria italica*) is cooked as a sweet pudding, while chickpea (*Cicer arietinum*) is used for making *bhaji*. Pudding using groundnut (*Arachis hypogaea*) is also prepared during the festival day of *Ugadi*. Though the region is small in size, it has contributed significantly to Telugu, Tamil, and Urdu languages, art, culture, and literature.

### Technology and products

The absence of perennial rivers, low rainfall, and unpredictable weather conditions have resulted in the evolution of a network of water tanks constructed from the olden times with the support of the public and the rulers, a process that continued even during the British colonial period. For these reasons, the area is known as a land of water tanks. In addition, for improved management of water, reservoirs (*cheruvus*) were developed to store runoff water in Chittoor and Kadapa districts of the region. *Cheruvus* are embankments that are fitted with *thoomu* (sluices), an artificial passage for water fitted with a valve or gate for stopping or regulating the flow; *alugu* or *marva* or *kalju* (flood weir), a barrier across the passage designed to alter the flow; and *kalava* (canal), channel for water discharge.

Traditionally, pastoral farming is an important strategy adapted in the upland areas of southern Deccan, particularly among resource-poor farmers, because of

the low rainfall, and the dominant floristic expanses of savannah grassland and thorny thickets of *Albizia*, *Amara*, and *Acacia* species. This has led to the domestication of animal species from early times, evolving and conserving genetic diversity in the form of potentially valuable breeds in several groups of animals, including poultry. Apart from this, the favorable agro-econiches for irrigation of agriculture in the riverine areas, the region is hospitable first for pastoral economy and second for dry farming (the chief soil types are red and black sandy loams) based on gravity flow irrigation. The pastoralists of this region are *Kuruvas* (called *Kuruma* in Telangana, and *Kuraba* in Karnataka) and the *Gollas*. The chief economy of the *Kuruvas* and *Gollas* is sheep/goat and cattle pastoral farming with exclusive or mixed herds. This postaralism falls in herdsman husbandry. *Kuruvas* and *Gollas* live in permanent dwelling of villages and are involved in field agriculture in a supplementary capacity.

Further, as the region is endowed with rich livestock and land resources, most of the farmers rear livestock, particularly resource-poor farmers. Under this major and important agricultural economic activity, the local people have evolved several indigenous breeds, particularly among cattle, which in the recent past have significantly contributed to the international pastoral farming with the sharing of their germplasm, which have been extensively used in breeding programs. For example, the *Ongole* breed, which originates from Guntur, Prakasam, and Nellore districts of south-coastal Andhra Pradesh, is adapted to a hot, sultry climate. *Ongole* oxen are large,

muscular, and strong with short horns, wide legs, and a big hump. They are white and glossy in color with black spots on the head, hump, legs, dewlap, and tail. The dewlap is large, pendulous, and hangs in folds (Fig. 2). It is a dual-purpose breed: producing bulls good for heavy draft work, and the cows with an average milk yield of 6–14 L per day. The germplasm of *Ongole* has been exported to other countries. It is a very popular beef-purpose animal in countries like Brazil. Another breed, *Punganur*, found in Chittoor district is the world's shortest, humped cattle. Animals are white and light gray in color with a broad forehead and short horns. Its average height is 60–100 cm, and its weight is 115–200 kg. It is an amazingly efficient milker with an average milk yield of 3–5 L per day on a daily feed intake of 5 kg. Similarly, the *Hallikar*, though originated from Mysore, Karnataka, is a very favorable/popular choice of the Chittoor farmers, who call it the *Ulsoor*, because of its desirable traits. The *Hallikar* is tall and strong, known for its nimble and swift movements. Its racing abilities are due to its long and slender limbs. Gray to dark



**Figure 2.** The elegant *Ongole* dual-purpose breed of cattle that has contributed to global farming.

***Recent, preliminary archaeobotanical results have produced further evidences to suggest that, with regard to plants, the earliest agriculture in South India (predominantly including parts of this region) dates back to the third millennium BCE.***

gray in color, it has deep shadings on its fore and back quarters. Its horns are dark gray in color, carried backwards, forwards, and slightly inwards. It is a poor milker, with a milk yield of 1–3 L per day. Nevertheless, *Hallikar* germplasm has contributed to the development of breeds like *Amrit Mahal* and *Khillari*. The population of *Hallikar* is declining, needing immediate conservation efforts. Another breed, *Turinjithalai*, bred by Telugu-speaking people in areas bordering with Tamil Nadu is known for drought hardiness.

Despite the potential economic value of these breeds for sustainability of lives under the harsh dry environment and the desirable traits, such as being more resistant to several diseases and sturdiness under dry conditions (though with lower per capita productivity), all these breeds from the region unfortunately are under neglect and threat, needing strong conservation measures for continued and sustainable use. For example, the *Punganur* is virtually on the verge of extinction with only some 30 animals left. It is presently being reared on the Government Livestock Farm, Palamaner, Chittoor district. But, in general, not much attention is being paid to the declining population of these indigenous breeds.

Similarly, in the case of sheep, breeds like *Deccani* (central peninsular region), *Bellary* (Bellary district), *Kenguri* (Raichur district), and the *Nellore* with three varieties based on color (indigenous to Nellore and parts of Prakasam) are known globally and are suited to arid and semi-arid environment. They are being used in breeding programs to harness desirable economic gains. In poultry, the development and conservation of breeds like *Aseel* has contributed globally. It has been considered as the chief resource for developing the different broiler breeds across the world.

To support pastoral farming, grazing over savannah grassland and thorny thickets is the main activity. However, overexploitation of these bioresources has been resulting in degradation and depletion of forests, leading to the loss of valuable biodiversity with degradation of climate and land. Nevertheless, the local tribes of the region have evolved practices for the use of residues of various food crops as fodder, as the main source of food for the livestock (60%), possibly recognizing the above environmental consequences and to ensure food support to domesticated livestock throughout the year.

To supplement the livelihood and ensure availability of food and fodder throughout the year, the local tribes also progressed

***Andhra Pradesh's earliest appearance is found in Aitareya Brahmana (800 BCE) as Dakshina Padh, a gateway to South India.***

with developments in field agriculture, suited to the predominantly dry climate. This resulted in the evolution of rainfed, dryland agriculture, with crop species (both indigenous and introduced) requiring less water or with better water-use efficiency and/or genotypes tolerant to drought in most crops. For example, in minor millets, variability exists in the form of landraces with different desirable features (Fig. 3). Several of these landraces have resulted in the selection of varietal products. For example, in foxtail millet the variety SrA 326 is a selection from the local landrace from Garladinne village of Kurnool district (Seetharama *et al.*, 2006). In finger millet, sources of several physiological traits have been identified, such as GE-94 with low stomata number, low leaf area, high photosynthetic efficiency, and higher water-use efficiency under stress, and DES-172 and PR-202 for good germination in crusted soil. Besides, the unique landrace IS-530, with bristled ears from the Andhra Pradesh area and genotypes like GE-187, with low stomata number, low leaf area, high photosynthetic efficiency; GE-1097



**Figure 3. Promoting traditional minor millets** (Source: [www.deccanherald.com](http://www.deccanherald.com)).

*The well known tribes of the region are the Gonds, the Sarvas, the Bagatas, the Mandulas, the Yenadis, the Chenchus, the Gadabas, the Yerukulas, the Sugalis, and the Mathuris. The Banjaras (or gypsies) appears to be a later entry. The other major tribes are Jatapus, Khonds (Samantas), Kondadoras, Konda Kammaras, Konda Reddis, Koyas, Nuka Doras (Muka Doras), Savaras, and Valmikiis. Some Negritos tribes like Irulas, Kodars, Paniyans, and Kurumbas are also found in patches.*

with high leaf area, high dry matter, and moderate to high photosynthetic efficiency; GE-2338 with higher water-use efficiency under stress, high biomass production, and high harvest index (>35%); GE-1179, GE-2327, GE-500, GE-3302 with high biomass production and high harvest index (>35%), and IE-2643, IE-3200, IE-2333 with drought tolerance from Karnataka area have been collected. In Karnataka, unlike other regions, the pearl millet landraces are late and tall with larger and broad leaves and small spikes.

In rice, the region is known for variability in sticky nature of rice and the popular varieties, like *Sona Masuri*. The other common farmers' varieties from the region are *Thella sanna vodlu*, *Yerra sanna vodlu*, *Bandapalaka vadlu*, *Budamodlu*, *Basmati*, and *Vonkodlu*. In addition, there are varieties with specialized features, like *Chennangi Vadlu*, a variety with horns-glutinous contents, grown in



patches where the farmers have saline/alkaline soils, and scented varieties like *Gangasara vadlu* grown by a handful of farmers. Some of these have contributed to the development of varieties like RNR through selection. In bread wheat, the Karnataka area is known for variability in grain weight per spike, 1000-grain weight, and grain color. In durum wheat, the region is known for variability in leaf color at fifth leaf stage, spike-awn length, grain weight per spike, grain number per spike, 1000-grain weight, etc. (Singh *et al.*, 2006). In Karnataka, even *dicoccum* wheat is grown. *Triticum dicoccum* (emmer wheat) variety *Khapli* is known to have curative properties for treating diabetes and cardiovascular diseases. It is well known for quality, stem rust resistance, and is being widely used in breeding programs.

Among pulses, significant variability has been observed in crops like pigeonpea, in the form of landraces like *Natu kandi*, *Peda kandi*, *Tota kandi*, and in field bean with landraces *Anapa* and *Natu anumulu*. Among oilseed crops, significant genetic diversity has been observed in Karnataka in the case of niger, for medium seed size, and high oil content (40–43%). The drought-tolerant selections No.71 (KRN1) and RCR66 are from local landraces of Raichur (Duhoon *et al.*, 2004).

***Nevertheless, Hallikar germplasm has contributed to the development of breeds like Amrit Mahal and Khillari. The population of Hallikar is declining, needing immediate conservation efforts.***

***Similarly, in the case of sheep, breeds like Deccani (central peninsular region), Bellary (Bellary district), Kenguri (Raichur district), and the Nellore with three varieties based on color (indigenous to Nellore and parts of Prakasam) are known globally and are suited to arid and semi-arid environment.***

Also, in safflower, the variety A-300 has been derived from a local landrace.

Among vegetable crops, the region has recorded high variability in brinjal (*Solanum melongena*) represented by landraces such as *Sanna vanga*, *Saara vanga*, *Tella mulaka*, and *Tella vanga*, and in chili (*Capsicum annuum*) for fruit color, shape, size, and plant type. Similarly, variability has been recorded in okra for various desirable features related with the fruit. In onion, the variability for bulb traits has been found in landraces such as *Chinna erragadda*, *Erra gadda*, and *Tella gadda*.

There is significant variability in ginger and turmeric. The region is also known for variability in seed spices like coriander, where several varieties have been developed from local collections through mass selection. For example, *Sadhna* was developed from the Alour collection, *Swathi* from the Nandyal collection, and *Sindhu* from a local collection (Ravindran *et al.*, 2005), and APHU Dhania-1 from a landrace (SH-3466/LCC-170/NIC-18231/IC-574503) from Koikuntla in Kurnool district.



The region is known for variability in tropical fruits. For example, in mango, the variability is represented by some of the popular traditional varieties such as *Banganpalli*, *Totapari*, *Cherukurasam*, *Himayuddin*, *Suvarnarekha*, etc. The custard apple, though introduced in the recent past, has shown good adaptability to diverse ecologies of the region, showing significant variability in fruit traits.

For useful and profitable cultivation, the region has developed some unique practices and intercropping systems; for example, intercropping of marigold with chili for control of pests and nematodes. Besides, botanicals like neem (*Azadirachta indica*) are widely used for control of insect pests. Neem is being traditionally used by the local farmers for manuring and pest control of paddy. Neem cake, after oil extraction is used for application to crops. However, the direct use of neem seeds is known to be more effective than the oil cake. Neem seeds are collected during the season and are crushed and applied to the plots.

In addition, the local people have identified and have been using a number of alternative sources of food, which can be considered as under-utilized edible greens and fruits, which serve as life-supporting species during periods of scarcity caused by vagaries of monsoon rains. The forest areas of the region are known for sandalwood (*Santalum album*) and the red sanders tree (*Pterocarpus santalinus*), which are considered sacred, but are under severe threat because of overexploitation from the natural habitat.

## Future perspective

Because of unsuitable government policies, farmers have switched over to paddy cultivation from coarse cereals. Since paddy is not the traditional crop of the region, this has led to digging of dug-wells and tube-wells indiscriminately leading to depletion of the water table, and drought followed by drought, forcing the farmers to leave the major part of their drylands as fallow lands. This has resulted in the spread of fallow lands on the one hand, and migration of farmers to nearest towns and cities in search of livelihood on the other, needing reinvention of traditional practices for sustainable agriculture.

The change in cropping pattern towards water-intensive crops is also creating problems of irrigation and depletion of groundwater and incidence of land degradation in Rayalaseema regions, where agriculture was predominantly dryland-based, dependent on rainfall (Reddy, 2003). Degradation in some parts of the regions has reached irreversible levels leading to desertification. Erosion due to water and wind is leading to the degradation of agricultural lands on the one hand, and dwindling of green cover in the common property resources and forestlands on the other, accelerating the desertification process. The direct erosion due to floods and surface runoff and indirect erosion due to excess or inappropriate use of water is also causing salinity and alkalinity in some areas. This situation demands greater research on management of natural resources, particularly water, and re-exploring of traditional systems for combating drought,

famine, and unsustainable agricultural progress.

Also, there is rampant deforestation along the steep slopes causing soil erosion and gully formation in this region. Practicing of unsustainable farming by the farmers along gradients without appropriate contour bounding are other major constraints affecting the productivity of the land, besides the severe drought during the growing period. Dwindling forests and pastures due to grazing and preference of land use for cash and commercial crops are also adversely affecting the fodder availability and thereby sustainable pastoral farming (Fig. 4), the principal pillar of the agricultural economy of the region, needing research attention for appropriate mitigation measures.

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**Figure 4.** Pastoralists face a grim future in the region because of degrading natural resources (Source: [www.hindu.com](http://www.hindu.com)).

perusing the manuscript and sharing some information.

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