This leaflet highlights the nutritional and socio-economic potential of tamarind and provides information to assist those working with the species. The focus is on conserving genetic diversity and promoting sustainable use of tamarind. The leaflet presents a synthesis of current knowledge about the species. The recommendations provided should be regarded as a starting point, to be further developed according to local or regional conditions. These guidelines will be updated as new information becomes available.
Tamarind is widely distributed in Africa and Asia. Its origin is unknown, although it is commonly believed to be indigenous to the drier savannahs of tropical Africa. However, it has long been naturalized in tropical Asia. Tamarind is now cultivated throughout the tropics and is economically important all over South-East Asia. It was introduced to the tropics in the western hemisphere in more recent times, probably during the early years of the West African slave trade. The capital of Senegal, Dakar, was named after the local word dakar for tamarind.

The species is thought to be native to Burkina Faso, northern Cameroon, Central African Republic, Chad, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Kenya, Madagascar, Mali, Mozambique, Niger, Nigeria, Senegal, Sudan, Tanzania, Uganda and Zimbabwe.

**Geographical distribution**

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**Importance and use**

Tamarind is used as a source of food, food preservatives, fodder, drugs, timber and firewood. Tamarind fruit pulp is very rich in tartaric acid and it is used as a preservative in the pickle industry. The hard green pulp of unripe fruit is too sour to be consumed directly, but is often used as a component of savoury dishes.
The ripe fruit is edible and popular, as it is sweeter, but is still very acidic. It is used in desserts such as jam, blended into juices or sweetened drinks or eaten as a snack. It is also consumed as a natural laxative. The species has many traditional uses in different societies in Africa.

<table>
<thead>
<tr>
<th>Uses</th>
<th>Part of plant</th>
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<tbody>
<tr>
<td>Food</td>
<td>Fruit, leaves</td>
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<tr>
<td>Beverage</td>
<td>Fruit</td>
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<td>Preservative</td>
<td>Fruit</td>
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<td>Fodder</td>
<td>Pods, leaves</td>
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<tr>
<td>Fuel wood</td>
<td>Stem, branches</td>
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<tr>
<td>Medicines</td>
<td>Leaves, fruit, bark</td>
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<tr>
<td>Fishing</td>
<td>Flowers</td>
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<tr>
<td>Soil protection</td>
<td>Whole tree</td>
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<tr>
<td>Timber, furniture</td>
<td>Wood</td>
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<tr>
<td>Recreation</td>
<td>Whole tree</td>
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Tamarind fruit and other products are sold on local markets in Africa as well as on international markets. Trade in tamarind products is an important source of income for farmers in Kenya. The fruits are also commonly marketed in Karamoja, West Nile and Northern districts of Uganda, and children sell the fruit in Ethiopian towns and coastal towns in Kenya.

**Socio-economic value**

Tamarind grows well under a wide range of soil and climatic conditions, but prefers semi-arid areas and wooded grasslands. It is commonly found on light clay (especially red clay), loam, sandy and alluvial soils as well as in rocky areas. It prefers well-drained alluvial soil with an average rainfall of 250–1200 mm per annum. It has an altitudinal range of 0–1600 m above sea level. The species is found along rivers in drier regions.

**Ecology and biology**

Reproductive biology

The reproductive biology of tamarind has been relatively well-studied compared with other African fruit species. Flowering coincides with the production of new leaves. The flowers are showy and aromatic, hermaphroditic (i.e. both male and female) and likely pollinated by bees.
Flowers are receptive for pollination for almost 48 hours. Self-pollination often results in flower or fruit abortion, indicating partial incompatibility.

**Phenology**

Trees usually begin to produce fruits at between seven and ten years of age. Humans and other large animals are the primary dispersal agents.

Flowering and fruiting times vary between countries. In Kenya, for example, flowers appear at the same time as new leaves, from April to July. Fruiting occurs from May to August and fruits reach maturity from December to February. In Niger flowering starts in December and ends in May. Fruits reach maturity from December to January.

**Related species**

Tamarind is the only species in the genus Tamarindus.

The tamarind tree grows to 14 m in height and has a dense, spreading crown with a clear trunk. It is considered an evergreen but may have a short deciduous phase in some areas. Leaves are compound and long, with 8–18 pairs of leaflets. Flowers are small, yellow with pink streaks and grow in small clusters. The fruit is a pod 5–15 cm long, with up to ten seeds embedded in a sticky pulp. The seeds are dark reddish-brown or black with a hard seed coat.

The species shows a remarkable variation in leaf size, tree form and fruit shape, taste and size. Different varieties have been reported from the areas where the species has been introduced and widely planted.

Tree growth is slow, less than 1 m per year. Trees established from seed generally do not start to produce seed until they are at least seven years old, while trees from
grafts usually bear fruit within three to four years.

**Genetic knowledge**

In spite of the species’ high value and widespread use, little is known about the genetics of African populations. Early studies established that it is a diploid species with 24 chromosomes. Preliminary results from provenance trials in Burkina Faso, Mali and Senegal indicate that the variation in growth, biomass and fruit production among different seed sources is substantial, but results have not yet been published.

A molecular analysis of genetic diversity showed that populations differ between East and West Africa. The population from Cameroon had the greatest diversity among the 10 populations tested, which included populations from Guadeloupe, India and Thailand, as well as from Burkina Faso, Kenya, Madagascar, Réunion, Senegal and Tanzania. Relatively high genetic diversity was reported across the range of the species, indicating that there is no immediate cause for concern about genetic erosion as long as conditions allow regeneration of seedlings.

**Local practices**

Farmers select trees based on fruit taste and other important traits. Management of trees differs between those from which fruit is to be harvested for domestic consumption and those from which fruit is to be sold. For example, in the region of Ishiara, eastern Kenya, a particular tree with exceptionally sweet fruits was communally owned, such that all members of the community could harvest fruit for domestic consumption.
use but not for sale, while other trees, which were less sweet, were allocated to different households, which were allowed to sell the fruit.

**Threats**

The main threats to tamarind include charcoal production, exploitation for timber, expansion of agricultural activities and overgrazing. Urbanization, climate change (drought) and exploitation for medicinal use pose less immediate threats.

**Conservation status**

Tamarind is considered endangered in the Lake Victoria region but is locally common in other areas. It is unknown whether tamarind occurs in protected areas such as parks or forest reserves.

Seed is orthodox so ex situ conservation in seed banks is feasible, though no seed banks have yet been established. Provenance trials are a form of ex situ conservation if they are maintained properly. Forty-four provenances have been planted in four provenance trials by INERA, Burkina Faso, but each with only one test site. Clonal genebanks have been established at tree seed centres in Burkina Faso (CNSF) and Senegal (PRONASEF) with populations from Burkina Faso, Kenya, Mali, Niger and Senegal.

Trees are generally protected from cutting on farmers’ land but the shade they provide is too dense to allow crops to grow beneath the trees. Tamarind suppresses the growth of other species nearby and is thus not as suitable for use in agroforestry systems as other forest fruit trees. In many areas little regeneration is observed, which may be cause for concern.

**Management and improvement**

**Selection and domestication**

Tamarind is not planted in the Sahel region but it has high potential for domestication. Plus trees were selected by the World Agroforestry Centre in collaboration with farmers.
in 2004–2005 in Burkina Faso, Kenya, Mali, Niger and Senegal and were cloned for use in tree improvement programmes. The selection criteria were vigour, early fruit set, fruit sweetness, resistance to pests and disease, long straight pods, large round canopy, high number of seeds and of pods, and ease of removal of fibre and shell from the fruit pulp.

In Asia, tamarind has a long history of cultivation and intensive management is practised in some areas. For example, the young trees are pruned so that 3–5 branches form the main structure.

Propagation from seed
Seed must be pretreated to achieve good levels of germination (80%). Pretreatment consists of pouring hot water (80°C) over the seed and then leaving the seed to soak in the cooling water for 24 hours. Alternatively, the seed coat can be nicked to facilitate germination. Pretreated seeds should be sown in germination beds or directly into potting tubes. Germination takes place within a week after sowing. The seed should be covered by 1.5 cm loose, sandy loam or by a mixture of loam and sand. Seedlings should be at least 80 cm tall before they are transplanted into the field at the onset of the rains.

In a pure-stand plantation, tree size can be controlled by close spacing (about 500 trees/ha) and pruning to promote fruit production. The World Agroforestry Centre recommends a spacing of 13 x 13 m when establishing the plantation from seed. Spacing may be reduced if using vegetatively propagated plants, which do not grow as large as trees established from seed.

Vegetative propagation
Tamarind can be vegetatively propagated easily and reliably using grafting and budding techniques. Grafted trees bear fruit within three or four years, compared with at least seven years for trees from seed, so are more appealing to farmers than seedlings.

Effective conservation of tamarind will require action in four main areas: in situ conservation, ex situ conservation, education and research. In order to ensure that wild populations of vulnerable species are maintained, protected habitats that will allow natural processes to continue undisturbed should be designated and monitored.

Ex-situ conservation involves establishment of plantations, maintenance of living collections in farm fields, home gardens, botanical gardens and arboreta located outside the zone of their natural occurrence.

Guidelines for conservation and use

Research needs

— Determine conservation status of existing populations and threats to their continued existence
— Determine the number of viable populations in protected natural areas such as national parks
— Determine effective population sizes in semi-natural farmland populations and minimum viable populations for conservation and long-term sustainable use
— Determine genetic variation in drought tolerance and location of important sources of variation
— Determine genetic variation in tree growth and fruit production by establishing additional provenance and progeny trials
— Identify pollinator species, investigate effective pollen flow and determine threats to pollinator species
— Investigate effectiveness of seed dispersal and degree of dependence on fauna that are rare or threatened
— Develop seed handling methods to enhance potential for ex situ conservation.


