Conservation and Sustainable Use of Genetic Resources
of Priority Food Tree Species in sub-Saharan Africa

SAFORGEN

Adansonia digitata

African baobab

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An old baobab tree in Semeré Centre (North Benin)

Common name	Scientific name	Synonyms	Family
African baobab, baobab, monkey bread tree, Ethiopian sour gourd, cream of tartar tree, upside down tree (English) Baobab, arbre aux calebasses, arbre de mille ans, calebassier du Sénégal (French)	*Adansonia digitata* L.	*Adansonia baobab* Gaertn., *Adansonia digitata* var. *congolensis* A. Chev., *Adansonia integrifolia* Rafin., *Adansonia scutula* Steud., *Adansonia situla* Spreng., *Adansonia somalensis* Chiov., *Adansonia sphaerocarpa* A. Chev., *Adansonia sulcata* A. Chev., *Baobabus digitata* Kuntze., *Ophelus sitularius* Lour.	Bombacaceae

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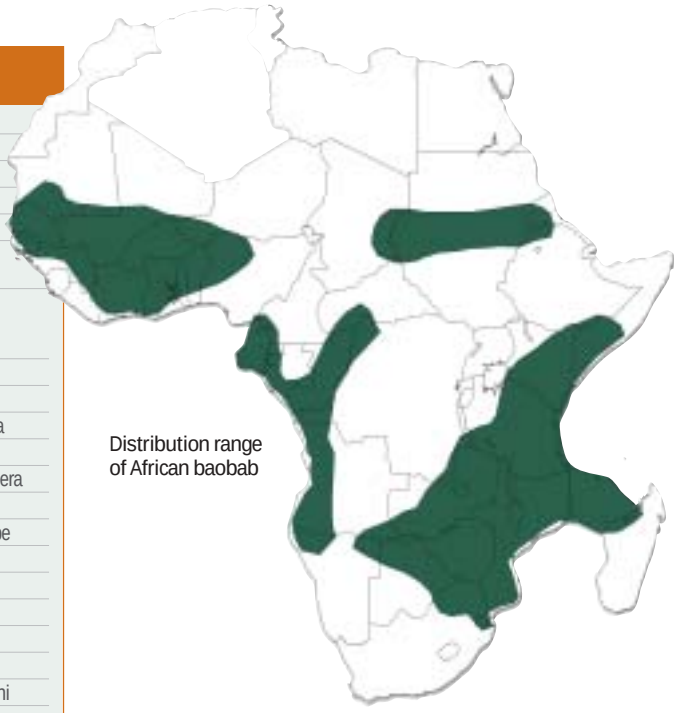
This leaflet highlights the nutritional and socio-economic potential of African baobab and provides information to assist those working with the species. The focus is on conserving genetic diversity and promoting sustainable use of African baobab. The leaflet presents a synthesis of current knowledge 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.

Socio-cultural group	Country	Vernacular name
Fon / Goun	Benin	Kpassa
Yoruba/ Nago	Benin	Oscké
Dendi	Benin	Kôô
Bariba	Benin	Sônbu
Ditamari	Benin	Moutomu
More	Burkina-Faso	Trega, twega, toayga
Senufo	Burkina-Faso, Côte d'Ivoire, Mali	Ngigne
Baule	Côte d'Ivoire	Fromodo
Amhara	Ethiopia	Bamba
Tigre	Ethiopia	Hemmer, dumma
Meru	Kenya	Muramba
Masai	Kenya,Tanzania	Olimisera ol-unisera
Yao	Malawi	Mlonje
Chichewa	Malawi	Mnambe, mlambe
Nkonde	Malawi	Mbuye
Dogon	Mali	Oro
Sonrai	Mali	Konian, ko
Dierma	Mali	Konian
Bambara	Mali	Sira
Fulbe	Mali	Babbe, boki, olohi
Mandinke	Mali	Sira, sito
Fulbe	Nigeria	Boki, bokki
Hausa	Nigeria, Niger	Kouka, kuku
Wolof	Senegal	Goui, gouis, lalo, boui
Serer	Senegal	Bak
Dirla fogny	Senegal	Boubakakou
Somali, Kamba	Somalia, Kenya Somalia,	Yag, mwambo
Kiswahili	Mozambique, Tanzania	Mbuyu, majoni ya mbuyu
Afrikaner and others	South Africa	Kremetart, kremtartboom,mubuyu, muyu, mbuyu, mkulukumba, mlambe
Zulu	South Africa	Isimuhu, umshimulu
Arabic	Sudan	Tebeldi, homiera
Ndebele	Zimbabwe	Umkhomo



Distribution range of African baobab

Geographical distribution

African baobab occurs naturally in semiarid regions of tropical Africa, including most countries south of the Sahara except Liberia, Uganda, Djibouti, Burundi and the Central African Republic. In Chad, it is found only in the west, and in South Africa it is mostly limited to the Transvaal.

It is found in diverse ecosystems including coastal areas of both eastern and western Africa. The northern limit of its range is where semi-desert scrubland begins. In the east, from Eritrea to Mozambique, it is typically found in the lowlands, but it occurs in the Nuba Mountains in Sudan. In Tanzania it also occurs on upland plateaus that have otherwise been cleared for cultivation. It occurs in mature woodland in Namibia, as a component of savannah ecosystems throughout Zimbabwe and northern South Africa and in both ecosystem types in Angola.

Importance and use

The African baobab tree is extremely important for humans and animals in the dry areas of Africa. It offers shelter and provides food, fibre and medicine, as well as raw materials for many purposes.

African baobab leaves are an excellent source of protein, containing all the essential amino

acids, as well as most of the non-essential amino acids. They also have high contents of minerals and vitamins A and C. They are used fresh as a leafy vegetable or are sun dried, milled and sieved to produce a green powder used as a flavouring agent in sauces in many parts of Africa. In most African countries where *Adansonia digitata* is found, the leaves are used as a leafy vegetable and are collected and sold by many households. In the southern part of the continent, people collect fruit and seeds and sell them to local companies that make oil from the seeds and package fruit pulp.

The fruit pulp is a dry, mealy powder when ripe. It is either eaten fresh or added to cooked gruels. Avoiding cooking the fruit pulp preserves the vitamins in it. The pulp is also mixed with water or milk to make a drink or used as a supplement mixed with staple foods such as corn meal and cassava.

Seeds and kernels are widely used, despite the thick hard shell. Seeds are commonly used to thicken soups, but they are also fermented and used for flavouring or roasted and eaten as snacks. Seeds are also a source of cooking oil but this use is not widespread despite a current deficit of vegetable oils in many areas where the baobab grows. Shoots and roots of germinating seeds are edible, as are taproots of young trees, but they are not widely consumed.

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A baobab used for food in a household (on the left)

Baobab products show promise for use in a new generation of foods and drinks; they have high nutritional value and useful processing properties, e.g. high pectin and fibre content, and there are a variety of claims of health benefits from consuming them.

The baobab tree also provides fibre from the bark, used for making rope, fodder for livestock (leaves) and medicinal products made from various parts of the tree and used to treat a variety of medical problems. Leaf extracts are very effective against dysentery. They are also

diuretic, diaphoretic, tonic and generally used against fever, diarrhoea, dysentery, colic, lumbago or ophthalmia, Guinea worm and urinary tract infections. They are also effective in the treatment of asthma. The bark is used to treat malaria, inflammation of the digestive tract, dental caries, rickets, anorexia and lumbago. The roots are used as a tonic indicated for the treatment of malaria. The fruit pulp is used in healing and strengthening children, treating diarrhoea, dysentery and inflammation of the intestine and liver. The seeds are used in the treatment of dental caries, gingivitis, malaria, measles and gastritis. The sap is given to stop tooth decay. The gum used as a disinfectant for wounds and in the treatment of toothache.

Socio-economic value

Baobab products are sold primarily in local and informal markets. The products commonly sold are leaves (fresh and dried), fruits, craft products and bark (fibre) products. As such, the species is a source of revenue for local households.

There is little documentation of trade in baobab products. Oil, used in cosmetics, and bark fibre for rope are exported to Europe but the quantity and monetary value of shipments are not known.

The many baobab products used locally and their unique properties offer considerable market opportunities, including food and beverages, botanical remedies and nutraceuticals and natural cosmetics. However, the potential will be realised only if the decline of the tree population can be halted and reversed.

Ecology and biology

African baobab occurs naturally in the Sahelian, Sudano-Sahelian and Sudanian zones, where the average annual rainfall is 300, 500 and 800 mm, respectively. It has been introduced in much wetter environments in Gabon and the Democratic Republic of Congo. It can withstand temperatures of up to 42°C, but it is very sensitive to frost and is restricted to areas with not more than one day of frost per year. The species thrives on a broad range of soils, from coarse-textured, free-draining soils to clay. It is frequently associated with tamarind (*Tamarindus indica*), Shea butter tree (*Vitellaria paradoxa*), African locust bean (*Parkia biglobosa*), Soap berry tree (*Balanites aegyptiaca*) and apple-ring acacia (*Faidherbia albida*).

The species is deciduous and is commonly without leaves for as long as eight months of the year. The leafless twigs contain chlorophyll and the trees can continue growing slowly

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Leaves processed into flour for cooking sauce

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Flower

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Fruit

Fruit, pulp and seeds

Seeds

during this time using water stored in the large trunk. Under good conditions trees grow very quickly in the early years, reaching 2 m in two years and up to 15 m in 12 years under good conditions. Baobab trees are thought to live for up to 1000 years or more.

Reproductive biology

Trees begin producing flowers when they are between 8 and 23 years old. The flowers are pendulous, grow singly or in pairs in the leaf axils, and are perfect, i.e. both female and male. Flowering time varies greatly, occurring at any time except during the peak of the dry season whether leaves are present or not.

The African baobab is pollinated by bats (*Edelon helvum*, *Epomophorus gambiensis* and *Rousettus aegyptiacus*), as are other members of the *Bombacaceae*. It is also thought to be pollinated by nocturnal insects and may also be wind-pollinated. Although its breeding behaviour has not been thoroughly studied, African baobab is thought to be generally out-breeding and this is supported by patterns of genetic variability.

Many seeds are embedded in the pulp of each fruit. The seed can lie dormant in the soil for several months, protected by its hard seed coat. Seed is orthodox, meaning that it can be stored using conventional storage methods.

Seed is dispersed primarily by humans, who harvest fruit for their own use and for local trade. Although the seeds have many uses (see above), many are discarded after fruit processing. Other mammals that disperse seeds include monkeys, baboons, elephants and rodents. Birds may also help seed dispersal.

Related species

There are seven other species in the genus *Adansonia: A. grandidieri*, *A. gibbosa* (A. Cunn.) Guymer ex D.A. Baum., *A. madagascarensis* Baill., *A. perrieri* Capuron, *A. rubrostipa* Jum. and H. Perrier, *A. suarezensis* H. Perrier and *A. za* Baill. *Adansonia gibbosa* is found only in north-western Australia. The other species are endemic to Madagascar but are also found widely in Africa.

Morphological traits and their variation

African baobab is one of the most striking and recognisable tree species in Africa because of its large size, swollen trunk and rounded spreading canopy. The bark is fibrous and ranges in colour from reddish-brown to black. On leaf bearing

Differences in tree shape

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Differences in bark colour

branches, a waxy surface covers a green layer that allows photosynthesis to continue when leaves have been shed. Leaves are usually palmate, with three to nine leaflets. Flowers are large and showy but short-lasting and nocturnal. The fruit is a capsule that hangs from a long stalk with a hard, woody shell 20-30 cm long. Numerous seeds (>100) are embedded in a yellowish-white pulp. The trees are anchored by a massive root system with lateral roots extending beyond the width of the canopy. Roots end with clusters of starchy tubers.

Four kinds of baobab have been described on the basis of their morphology: black-bark, red-bark, grey-bark and dark-leaf vegetable baobabs.

Variation in growth habit, vigour, size, fruit characteristics and vitamin content of the leaves has been reported from several countries. A study of morphological and productivity traits of populations from the Guinean, Sudano-guinean and Sudanian zones in Benin found significant phenotypic differences between populations in all traits studied. Trees were measured in their natural environments, hence differences in climatic and soil conditions may be directly responsible for much of the observed variation. Common garden field tests, in which seedlings originating from a range of environments are planted together in several representative environments, are needed to determine the degree to which the variability is heritable.

Genetic knowledge

African baobab, *A. digitata*, has a chromosome number of 2n=160, whereas the other baobab species have 2n=88. It is likely that there are several copies of some or all of the chromosomes in each cell. This means that interpretation of molecular genetic studies is more difficult than for species that have the more-usual two sets of chromosomes.

Preliminary results from provenance trials established at three sites in Mali in 2001 show no significant differences in growth between provenances. Molecular genetic studies have been carried out in West Africa (Benin, Ghana, Burkina Faso and Senegal) with a greater concentration in Benin. Variability in morphological traits was also assessed in the same populations in Benin. The analyses showed that, both within Benin and over the broader region, more than 80% of the genetic diversity was within populations and genetic

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A young baobab tree defoliated for food use

differentiation between populations increased with geographic separation. This indicates that there are no obvious barriers to gene flow between populations among the countries in West Africa, but as would be expected, the probability of seed or pollen transport diminishes with distance.

When gene flow is disrupted between populations for several generations, populations differ in a random manner and the degree of differentiation does not correspond to geographic distance. Although gene flow is evident, more distant populations differ significantly; however, in Benin genetic differentiation corresponds weakly to morphological variation. It thus appears that the evolutionary forces influencing the molecular markers used are different from those affecting the morphological traits studied.

Most African baobab populations that have been studied have similar levels of genetic diversity in random DNA sequences, with the exception of populations in Senegal, which show less diversity. The populations that are most influenced by humans showed slightly greater variability than those subject to less human influence, perhaps because some trees close to peoples' homes in the former populations originate from fruit purchased at local markets. In general, neighbouring trees were found to be related, which could lead to negative effects associated with inbreeding if populations shrink or pollination between unrelated trees is disrupted by landscape fragmentation.

Local practices

Baobab trees have great significance for many peoples in Africa. There are many legends about the tree and although in many areas mature trees are protected and highly valued, people in southern Benin consider the species diabolical and eliminate seedlings and saplings from their fields. Uses of the species differ in different areas, with uses ranging from keeping bees in the hollowed trunks in some

areas to storing water in areas where people are nomadic.

Rural people have used many criteria to differentiate baobab individuals in traditional agroforestry systems, including characteristics of leaves, fruits, bark and the whole tree. For example, in rural areas of Benin people favour baobab trees that are considered female (fruit producing), have delicious leaves, sweet or slightly acid fruit with yellowish pulp and good texture, capsules with high pulp yield and bark that is easily harvested. Some local beliefs that guide the selection of trees for harvesting include the following: hairy leaves are always tasteless; trees that do not produce fruit always have tasteless leaves; long, medium-sized fruits have sweet pulp; and trees with early or late fruit maturity always produce sweet pulp.

Threats

African baobab populations are declining and the tree is considered threatened in some parts of its range because of very little observed regeneration. The near absence of regeneration is attributed to intensification of agriculture, increased frequency of bush fires, grazing by livestock and over-exploitation, especially for leaves. Trees that are favoured for leaf harvest are frequently mutilated to prevent them from producing flowers. Seedlings less than 2 m in height are often pulled up by children, who eat the taproot. Bark is frequently stripped from older trees but the bark regenerates and trees survive considerable bark harvest. Changes in rainfall patterns and declines in rainfall also threaten the species in some areas.

Conservation status

Ex situ collections are stored using conventional methods in the national seed bank in Burkina Faso and at the Millennium Seed Bank, UK. Germination tests on seed that had been stored for 15 years showed that the samples maintained very high viability in storage. However, the number and sampling distribution of accessions are inadequate and the collections need to be expanded through systematic collection activities.

It is not known whether there is any effective *in situ* conservation of African baobab in protected areas such as national parks and forest reserves. Many officially protected areas are protected only on paper, so while it is likely that the species occurs in numerous protected areas, such occurrence may not constitute effective conservation.

The agroforestry literature suggests that the best option for conservation is *circa situ* conservation, which entails management and protection in production systems. However, the current effectiveness of this approach is in question, given that African baobab populations are reportedly declining throughout much of the range of the species where trees are included in production systems, because seedlings and saplings are not provided with inadequate protection to ensure their survival.

Management and improvement

Humans influence the viability of baobab populations in a variety of ways. Some practices are beneficial, such as transplanting and seedling protection as well as the unintentional dispersal of seeds through garbage disposal on fields, while others are detrimental, such as ploughing fields or allowing livestock to graze where seedlings are becoming established.

In Burkina Faso and Nigeria, rural people plant the trees around their houses or on their farms. In other countries the tree is not often planted from seed but seedlings are transplanted to field edges or close to houses. Young

trees require a high degree of protection, including fencing to exclude livestock grazing.

Selection and domestication

Domestication and improvement activities are underway in some international centres (e.g. the World Agroforestry Centre) and African research institutes. Research in Benin, Burkina Faso, Mali and Senegal has provided data on nutritional and medicinal value, agronomy, ecology and productivity and genetic diversity of baobab. Ongoing research includes morphological, ecophysiological and genetic characterization of plant material across agro-ecological zones to determine drought stress tolerance/resistance. All of these projects combine research, capacity building and knowledge transfer to aid in successful application of the results by rural people.

Propagation from seed

African baobab can be grown from seed but germination is often low. The seed may be adapted to germinate after passing through an animal's digestive system. Termites often bore through the seed coat of seed lying on the ground, increasing germination rate. The percentage of seed germination under controlled conditions is improved significantly by scarification before sowing. Methods include pouring boiling water over the seeds followed by soaking them in water for 24 hours and nicking the seed coat with a sharp blade. Germination can take anywhere from 3 weeks to 6 months. Young seedlings need adequate moisture to become well-established.

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A young grafted tree

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Baobab seedling production

Vegetative propagation

African baobab can be propagated from stem cuttings or by grafting. Grafting ensures that the young tree will have the same qualities as the tree from which the scion (twig used for grafting) was taken. They will also be shorter, which facilitates collection of fruits. Grafting also shortens the time to first flowering; trees established from seed flower after eight years or more, while those from grafts may flower after only three years.

Guidelines for conservation and use

Genetic resources of African baobab can be conserved *in situ* in natural areas, *circa situ* in managed agroforestry systems, or *ex situ* in seed banks or field genebanks. Baobab seeds exhibit orthodox behaviour, so they can be easily stored for long periods of time. Genetic conservation strategies should be based on knowledge of morphological variation, level of threats in different regions and the level of genetic diversity where known.

An old baobab tree in Semeré Centre (North Benin)

Conservation by *circa situ* methods, if accompanied by adequate education and farmer support, is probably most likely to succeed. Ideally this would entail development of several small-scale tree improvement and outreach programmes to ensure that farmers have access to good-quality seedlings and are encouraged to plant and protect baobab as an agroforestry crop.

Sampling strategies for *ex situ* conservation and for developing seed orchards aimed at supporting conservation through use must ensure that useful genetic variation is captured. Molecular genetic studies in part of the species range show that African baobab has high levels of genetic variation within populations, thus sampling a few populations intensively within a climatic zone will likely capture much of the neutral variation. It should be noted, however, that these studies did not evaluate traits that are important in adaptation or production; such traits are subject to selection so probably have a different distribution pattern from the neutral alleles. Thus it is important to sample the range of climatic conditions and especially to capture genes for drought tolerance. More-intensive sampling of populations occurring in areas of environmental extremes is recommended.

Research needs

- Determine genetic variation in drought tolerance and location of important sources of variability
- Determine the number of viable populations in protected natural areas such as national parks and the degree of actual protection
- Determine genetic variation in fruit production, nutritional value of leaves and other important production traits
- Determine effective population sizes in semi-natural farmland populations and minimum viable populations for conservation and long-term sustainable use. ■

Adansonia digitata African Baobab

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This leaflet was produced by members of the SAFORGEN Food Tree Species Working Group. The objective of the working group is to encourage collaboration among experts and researchers in order to promote sustainable use and conservation of the valuable food tree species of sub-Saharan Africa.

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