

Cordia africana (Boraginaceae) in Ethiopia: A review on its taxonomy, distribution, ethnobotany and conservation status

¹ Getu Alemayehu, ² Zemedede Asfaw, ² Ensermu Kelbessa

¹ Jigjiga University, College of Natural Sciences, Department of Plant Biology, P.O. Box 1020, Jigjiga, Ethiopia.

² Addis Ababa University, Department of Plant Biology and Biodiversity Management and the National Herbarium, P.O. Box, 3434, Addis Ababa, Ethiopia.

Abstract

The purpose of the review paper is to review existing literature on ethnobotanical knowledge of *Cordia africana* to assist in the proper utilization, management and conservation of the species. *Cordia africana* which belongs to the family of Boraginaceae is a deciduous forest tree widely distributed from South Africa to Saudi Arabia and Yemen at altitudes between 550 - 2600 m.a.s.l. and with an annual rainfall of 700 - 2000 mm. It occurs in primary or secondary forests and woodlands. In Ethiopia, it grows well in the dry, moist and wet weyna dega agro-ecological zone. *Cordia africana* has various uses as medicine, fodder, food, fuelwood, for making of juices and materials for culturale use. It is one of the most important indigenous tree species for making a variety of items used by the communities. It provides very good mulch and can be used in other mixed cropping systems on cropland, pastureland, to improve microclimatic conditions. *Cordia africana* is a forage tree for honeybees and flowers between March and October. Beehives are often hung on *Cordia africana* tree. It is therefore good for beekeeping and honey production. *Cordia africana* is also a source of excellent high-value timber that is suitable for furniture, mortars, windows and house doors. It is one of the major timber species in Ethiopia that have been exploited commercially. It plays an important role in generating local household income from the sale of products and conserving biodiversity. Business obtained from timber production severely accelerated the high rate exploitation of *Cordia africana*. It is locally threatened and is given protection by proclamation (Government of Ethiopia, Proclamation No. 94/1994). It is now managed by some farmers in their farmland as agroforestry tree, such management and acquisition of economic benefits from the species might promote local peoples' interest in conservation.

Keywords: *Cordia africana*, Fodder, Fuelwood, Medicine, Timber

Introduction

Cordia africana is an early colonizer in forest re-growth and is often found along forest margins; it often regenerates in clearings and forest gaps [30, 36]. On average, it attains a height between 14 and 21 m and a diameter at breast height (dbh) between 0.60 and 0.90 cm and shows great morphological variation [29]. Flowers are complete and pollinated predominantly by bees. The fruits are edible, and seed dispersal is mainly carried out by mammals and birds. *Cordia africana* is a fast-growing and highly valued timber tree in Ethiopia. It is moderately hard and durable wood makes it a valuable raw material for making high quality furniture and household materials [44]. It is also the most important multipurpose tree species widely occurring on croplands, grazing areas, homesteads and farm boundaries. For instance, it is a good source of medicine (bark, root), food (fruit), firewood and bee forage [19, 36, 53].

The contribution of scattered trees of *Cordia africana* to improve soil fertility and its importance as a (coffee) shade tree in traditional agroforestry systems has been documented [66, 77]. The current distribution, the habitats and the populations of *Cordia africana* are severely affected by deforestation, fragmentation and selective logging. Over-harvesting can threaten the species. Without management intervention, it may lead to the extinction of a species and loss of associated indigenous knowledge on use and management.

For this reason, this review is initiated to review existing literature on ethnobotanical knowledge of *Cordia africana* to assist in the proper utilization, management and conservation of the species.

Taxonomy of *Cordia africana*

Cordia L. (generic name after Valeris Cordus, a German botanist) is a pantropical genus of about 250 species belonging to Boraginaceae Juss. [43], a plant family comprising about 100 genera and 2000 species that are characterized by flowers in helicoid cymes and by coarsely hairy herbage [24]. *Cordia africana* Lam. (Synonym: *Cordia abyssinica* R. Br.) is a tree (rarely shrubby) species. Its English common names are East African *Cordia* or large-leaved *Cordia* or Sudan teak [43]. There is still no one language that all the people of Ethiopia have in common. The species has different vernacular names in different parts of Ethiopia; it is locally known by different names.

Botanical description of *Cordia africana*

Crown umbrella-shaped/rounded, dense, much branched; twigs velvety hairy, becoming glabrous (Figure 1). Bole typically curved or crooked [74]. Bark surface smooth in young trees, becoming cracked or longitudinally fissured with age, pale brown to dark brown, inner bark fibrous, whitish, turning grayish to nearly blackish upon exposure; [21]. Leaves

leathery, simple, alternate, broadly ovate to egg-shaped, rough to feel, dull dark green, rounded to cordate at base, rounded to acuminate at apex, margins entire to slightly toothed, pinnately veined with 5–7 pairs of lateral veins. Buds oval, stalkless, pleated open into flowers that are bisexual, white, sweet scented, shortly pedicelate or sessile, massed in compact panicles covering the crown, with a white mass of attractive flowers; calyx less than 1 cm long, strongly ribbed, back of lobes covered with short, soft, brown hairs; corolla lobes crinkled, white, long-exserted, funnel shaped, about 2.5 cm long; cymes many flowered (Figure 1).

Flowers funnel-shaped, pure white, sweetly scented, produced in quite large bunches. All the flowers on one tree open at the same time giving a very decorative effect. Fruit circular, up to 1 cm in diameter, yellow when mature and single-seeded [61]. The sweet sticky flesh is edible. Seeds ellipsoid to reniform, dark brown to black [58]. The seed coat is tough, leathery and waterproof. Seeding time is highly variable, but August–September appears to be the best season. Seeds remain viable at least for one year. However, best germination occurs with fresh seed. Germination begins in two weeks, proceeding unevenly for up to two or three months.



Fig 1: Vegetative and reproductive parts of *Cordia africana* Lam. A) Rounded crown B) Wood in transverse section C) Wood in transverse section D) Wood in tangential section E) Leaf shape F) Flower G) Matured fruit (Source: [57])

Reproduction of *Cordia africana*

Cordia africana begins flowering when a tree is 3-5 years old [43, 53]. It is monocious species with complete flowers (hermaphrodite) and is known to be pollinated predominantly by bees [74]. In Sudan, flowering occurs in October to December and fruiting from January to April; in Kenya, flowering is from April to June. It is repeated at intervals over several weeks and is evidently activate off by rain showers. After pollination by insects, fruit development takes a period of almost 6 months. In Ethiopia, the tree can be found in flower or in fruit all the year round, but the main flowering period of the species is from October to March [36]. A flowering tree is spectacular; all the flowers open within a short time and give the tree a white snowy cover [22]. Fruits of *Cordia africana*, are eaten and their seeds dispersed by birds, baboons, monkeys, apes and probably other animals [43].

Natural Distribution and Habitat

Cordia africana is native to Angola, the Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, Ghana, Guinea, Kenya, Malawi, Mozambique, South Africa, Sudan, Tanzania, Uganda, Zimbabwe, Saudi Arabia and Yemen [37, 74]; Figure 2). In Ethiopia, it is widespread in Broadleaved Afromontane

Rain Forests, Undifferentiated Afromontane Forests ('mixed *Podocarpus* forest') and in riverine forests as well as in the western lowlands [37]. Open places in moist montane forest, forest edges, in forest remnants around churches and other traditionally protected areas, as isolated trees in grassland and cultivated fields, in villages and public gardens of TU GD GJ WU SU AR IL GG SD BA and HA Flora regions [61]; Figure 3). In West Africa, this species is said to be restricted to montane and submontane habitats; it has limited distribution in the lowland habitats of the Democratic Republic of Congo [58]. Generally, the species grows in areas with altitudes between 550 and 2600 m.a.s.l. and with annual rainfall of 700 to 2000 mm [37]. It is an early colonizer in forest re-growth and is often found along forest margins; it often regenerates in clearings and forest gaps [30, 36]. It has a light quality sensing mechanism that hinders it from germinating beneath leaves [78]. It occurs in primary or secondary forests and woodlands [53]. It prefers regions with relatively high rainfall and sufficiently warm climate. It can also grow under drier climatic conditions, by minimizing its water consumption through shading its leaves or by closing its stomata [53, 40]. *Cordia africana* has fast growth performance, is culturally accepted and widely used and is adapted to local conditions [31, 53, 42].



Fig 2: Map of Africa showing countries where the species has been planted (Source: [58])

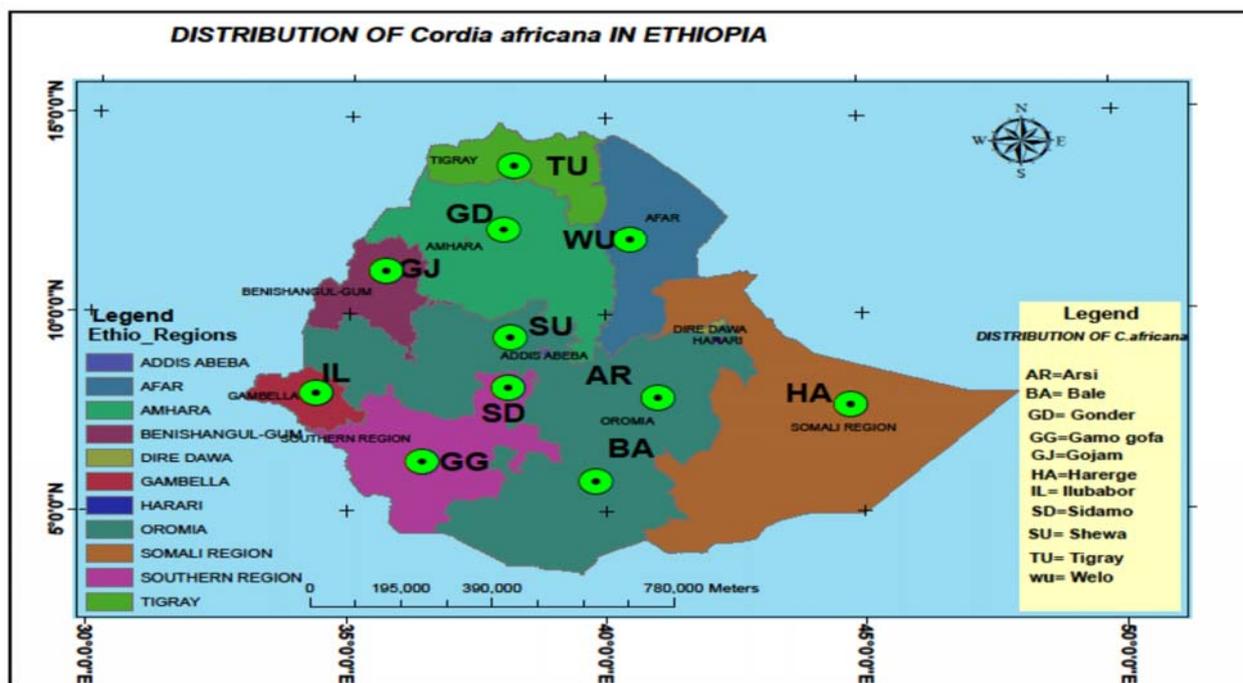


Fig 3: Natural distribution of *Cordia africana* in Ethiopian Flora regions (Source: [61])

Ethnobotanical uses

Medicinal uses

Medicinal plants have important contributions in the healthcare system of local communities as the main source of medicine for the majority of the rural population. Plants have not only nutritional value but also, in the eyes of the local people, they have medicinal and ritual or magical values [2]. The ethnomedicinal healing systems vary across cultures. In Ethiopia, there is cultural diversity with various patterns of using the flora [5]. *Cordia africana* is one of the main sources of traditional medicines serving to cure different diseases for human being and domestic animals. Several parts of the plant are used in traditional medicine. In Ethiopia, the medicinal uses of *Cordia africana* have been reported by different

authors for example, it helps to cure, Acute febrile [50]; Wound [9]; Cough, toothache, stomach ache [60]; Fire burn, Michi, diarrhea, jaundice, eye infection, tonsillitis [67]; Eye-problem, anthrax of cattle [27]; Epilepsy [20]; Urination at night [80]; Jaundice, malaria [11]; Chest pain [70]; Skin rash, smell of foot, scabies [34]; Tonsillitis [3]; Abdominal pain [13]; Evil eye [49]; Gastritis, sore [47]; Spider poison [10]; Fever and influenza [38].

Uses as fodder trees

Cordia africana plays an important role in animal production by providing fodder. Leaves of *Cordia africana* provide fodder for the dry season. According to [39], leaves are threshed, cut, or pitted and collected for livestock consumption. *Cordia africana* is left to grow sufficient wood

so that it serves as live fence around grazing units and farmyards; the tree is lopped periodically for fodder and sometimes fruits of the tree are consumed by cattle, goat, sheep, donkey and mule [8].

Bee forage

Cordia africana has good attributes as fodder plant for honeybee [37]. It has sweetly scented flowers and it is known for its high quality honey production. It is attractive to honeybees, and pollination is mainly effected by these insects [53]. The worker bees collect pollen and nectar from *Cordia africana* and manufacture honey that is harvested by the farmer [54].

Cordia africana supplies abundant pollen and nectar for bees which forage all day [36]. This is one of the major honey sources of Ethiopia mainly in the western parts. It also often contributes to mixed honeys in which its flavor predominates. The honey is very aromatic with a slow granulation and light brown in color. Crushed seeds, dissolved in water, can be used for feeding bees during dry periods [36]. According to [23], in Ethiopia beehives are often hung on *Cordia* trees when bees are swarming. In Maale community, South Omo, beehives are made from *Cordia africana* [59].

Household tools

The wood is light, yet durable, moderately soft, fairly straight-grained, and relatively termite and fungus resistant. *Cordia africana* is a fast growing and highly valued timber tree used for high quality furniture, doors, windows, chairs, beds, containers, cabinet-making, drums, interior construction, beehives, mortars and pestles [21, 32, 43]. In the western part of the country as log-hives for bees and TEJ (honey-beer) barrels are made from hollowed out stems of *Cordia africana* [36]. Mixed planting and closer initial spacing in plantations have been recommended to improve the growth performance of the species and minimize problems posed by big branches on the quality of the wood [48]. Thus, the demand for wood of *Cordia africana* by users of its timber and timber products is enormous.

Farm implements

The agricultural implements including plough, yoke, axe and digger are made from several plant parts supplemented with locally made metal instruments. For instance, plough is made from cut and curved woody-stem of *Cordia africana* estimated to be 2½ m in length [6]. The second part connected to a plough is a yoke (QANBARRII) made from stem cuttings of *Cordia africana* [6]. Stem part (2-3 m in length, 2 m in width) is cut, bark removed and open container is made by handsaw for feed service of livestock's [6].

Construction materials

Cordia africana has tough wood, which is used in hut building [1]. The wall of rural houses in Ethiopia is constructed by planting woody stems of *Cordia africana*. The roof consists of two layers; the inner layer is attached from vertically laid woody stems of *Cordia africana* and the outer is covered by a bunch of grass species. In Chaffa area the majority of rural houses have single door made from the timber of *Cordia africana* [65].

Binding and Drum making

The main type of Ethiopian handwritten book is the codex, made of folded parchment leaves, which are collected in gatherings, sewn together, and given covers. The codex (*māshaf*, *branna*) has dominated the local manuscript culture throughout its history. The main type of binding of the Ethiopian codex is relatively simple. The front and back cover boards are commonly made of *Cordia africana* (*wanza*), though other kinds of wood are also used [55]. Figure 4). They are cut roughly with an adze and rarely have a perfectly square form. In addition, the Asante-style drum is one of the earliest known surviving African-American objects, originated in West Africa which is made of wood of *Cordia africana* [26]. Figure 5).

Source of food

Cordia africana is used as a source of food [50]. In Tigray, it is collected and eaten by shepherds and children when found in the wild, and collected, and eaten or sold by women and children when grown in farms or backyards [71]. *Cordia africana* fruit is eaten by the local community during its fruiting season of April to June. Generally, the fruit is eaten fresh, however traditionally the fruit is also dried and kept for use during off season [71]. The fruits are eaten by baboons and humans [23].

Making of juices/Fruits subjected to some form of home processing

Mature fruits have a sweet, mucilaginous, edible pulp. The ripe fruit are collected either from the ground or picked from the tree and the pulps of fruits are eaten and seeds are discarded. The ripe fruits are also grounded and mixed with water and used as juices in ancient times [39]. A juice of *Cordia africana* is usually added to flavour local drinks prepared from other sources [72]. *Cordia africana* is processed into refreshing juice either by boiling or by adding lukewarm or cold water [72]. Fruits of *Cordia africana* are brewed either with the addition of leaves of *Rhamnus prinoides* to give the local alcoholic drinks, “*tela*” and “*tej*” or without it to give the local alcoholic drink “*Beerz*”. The juice of *Cordia africana* is sometimes diluted with water and sugar or honey may be added.

Fuelwood

Women tend to dominate the fuel wood supply chain. The wood is transported by the producers to local markets on either their own backs or on a donkey. An average fuelwood collector sells between 0.5 m³ and 1 m³ each market day. *Cordia africana* is used for fuel in Sidama Zone of Southern Ethiopia [5]. A number of protected indigenous trees, including *Cordia africana*, often find their way into fuelwood bundles in many market places [17]. The projected sustainable fuelwood supply is estimated to reach 8.6 million m³ in 2030 [17].

Environmental use

Cultivation of coffee involves planting of young coffee plants in the understorey of a remaining native tree cover, which principally includes *Cordia africana* [66]. Further, in southwestern Ethiopia, natural forests are also common where *Coffea arabica* grows as understorey plant [41]. *Cordia africana* is favoured as a shade tree for coffee because of its short bole. *Cordia africana* often found in cropland where it

is managed for shade. It provides very good mulch and can be used in other mixed cropping systems on cropland, pastureland, or rangeland to improve microclimatic conditions [66]. Generally the tree, provides shade and mulch for the integrated enset-coffee systems resulting in control of soil erosion, regulation of soil moisture and temperature, improved soil nutrition, eventually creating favorable conditions for crop growth [5].

Trees on croplands have been reported to improve soil fertility due to their organic inputs with nutrient recycling through mineralization [40, 51, 52, 81]. Comparison of soils from under tree canopy and areas away from the influence of the trees has been used to study the influence of trees on soils [56, 77, 81]. Trees usually become centers of variation in soil properties or 'islands of fertility' [82]. This variation is mainly caused by in situ processes (litter fall, root activities, nutrient cycling, etc. [77]). Even though many other external factors may also contribute to this variation (bird/wildlife droppings, weeds, cow dung, urine, etc.), [16, 56, 73].

Farmers in southern Ethiopia retain *Cordia africana* for maintaining soil fertility in enset-coffee based agroforestry [12]. *Cordia africana* is one of the common shade trees of coffee in Ethiopia [66]. It enriches soil fertility and productivity through litter fall that decomposes readily [69]. Studies by [56, 77] reported positive influence of *Cordia africana* on various soil fertility parameters.

Cordia africana trees scattered on crop fields and farmlands improved some soil properties in West Shewa [77] and Badessa [40] under their canopy as compared to the adjacent open plots. Due to its light canopy [42] and N-fixing ability [53], *Cordia africana* is popular in the southern region of Ethiopia [42, 45]. Available P content of subsurface soil was improved under *Cordia africana* [40].

The leaves provide very good mulch and can be used in other mixed cropping systems on cropland, pastureland, or rangeland to improve microclimatic conditions. Leaf fall in the dry season is heavy, and the leaves make good mulch, and it is not only serve as mulch but also contribute to nutrient cycling through decomposition [53, 68]. *Cordia africana* has good attributes for soil conservation [77].

On farms, it keeps soil nutrient high via protection against leaching, translocation of nutrients from deeper to the surface layer and accumulation of litter, which creates a temporary nutrient pool in the surface soils under its canopies [40]. Indigenous timber species, for instance, *Cordia africana*, is further appreciated for its soil improvement roles amongst other functions such as water catchment protection and certain cultural values [25]. Generally, tree species of *Cordia africana* play a great role in maintaining soil fertility and providing various products and services to the farmers [77].

However, the performance of the native tree species *Cordia africana* in south central highlands of Ethiopia in relation to understory species diversity in general, was found to be intermediate [63]. It appears that, it is the overstory species physical characteristics (crown size and density, clear bole length, tree height etc.), root competition and its influence on soil biological and chemical activities, which affects understory species composition [78].

Social use

Plants can be used for different social purposes including ritual, religious or spiritual ceremonies. In Oromo culture

when *buttaa* celebration takes place, especially in the *Raaba* stage, the specific duty of *abbaa kormaa* is to guide the bull at the head of the two lines of patriots (patriots of the *Raaba*). During the festival, those who have completed their eight-year initiation periods, slaughter animals, especially bulls (*korma*), and they hold a rod known as *woddeessa* (*Cordia africana*). The *woddeessa* as part of ritual performance represents great success and honour, [33]. *Cordia africana* provides shade as well as suitable places for conducting ceremonies and get-togethers for the villagers during social gatherings and religious holidays where coffee and snacks (of roasted grains) and bread may be served [64].

Commercial importance

Cordia africana is one of the most important indigenous timber trees of Ethiopia. It is used as a source of high-quality timber [19, 36]. It is one of the major timber species in Ethiopia that have been exploited commercially [4]. The income generated from the sale of its products and the timber itself is one of the mechanisms of making a livelihood for many rural poor people [76].

Cordia africana is an economically important and marketable species. It is the most preferred timber species and the timber fetches as high price at local market [14]. The wood is also sold to wood processing and furniture factories in towns and thus it contributes to income generation [5]. In general, income derived from the sale of wild plant species is of particular importance to the poorer households who must supplement food production with cash in order to meet basic needs [14].

Effect of growing space on growth and branching habit of *Cordia africana* trees

Cordia africana trees planted at wider spacing grew faster than those grown at narrow spacing. Therefore, planting *Cordia africana* trees at wider spacing on dry marginal lands could be beneficial in terms of growth; it avoids competition for soil moisture, light and nutrients in dry regions [46]. However, growing *Cordia africana* trees at wider spacing could be disadvantageous in terms of stem quality. Trees at wider spacing had bigger branches or knots than those at narrow spacing and bigger branches or knots are factors that degrade the value and quality of its logs [28]. Therefore, it is necessary to minimize the effects of these factors to increase the quality and value of wood from *Cordia africana* trees. To improve stem quality and enhance growth of *Cordia africana* trees, various studies suggest the establishment of closely spaced plantations followed by thinning as soon as the water and nutrient requirements of the planted trees increase.

Conservation status of *Cordia africana*

The current distribution, the habitats and the populations of *Cordia africana* are severely affected by deforestation, fragmentation and selective logging [30]. Severe natural forest destruction in Ethiopia particularly in the northern part of the country has forced the tree to have scattered occurrences in patchy natural forest, on farmlands, in graveyards and church compounds [75]. *Cordia africana* is the most preferred plant by local people for various uses and is the most threatened, which is evidently shown by its scarce distribution in Goma Wereda, Jima Zone of Oromia Region, except in some protected coffee forests [34]. This scarcity of *Cordia africana* is due to over harvesting for not only medicinal but also for

other uses particularly for timber production^[34]. Business obtained from timber production severely accelerated the high rate exploitation of *Cordia africana* because it is the commercially important indigenous tree species^[17].

Thus, the demand for wood of *Cordia africana* by users of its timber and timber products is enormous. However, supply is not keeping pace with the demand. Because this high demand has caused a rapid depletion of the species, the tree is now proclaimed as one of the most threatened tree species of Ethiopia^[18, 62, 76]. *Cordia africana* is one of indigenous tree species that have currently been identified and given conservation priority nationally by using in-situ and ex-situ conservation in the country^[60]. Field gene banks, botanical gardens and duplicate gene banks along with Cryo-preservation centers are being established in various localities to supplement the *in situ* conservation sites. The *ex situ* sites have been established in Lephis, Arsi Nagelle Wereda, Farta Wereda, Debre Tabor for *Cordia africana*. The Forest Genetic Resources conservation Department of the Institute of Biodiversity Conservation in collaboration with GTZ has started reintroducing the most threatened woody species including *Cordia africana*, into their natural habitats.

According to the Forestry Conservation, Development and Utilization Proclamation No. 94/1994 of Ethiopia, no person shall utilize or harvest *Cordia africana*. Private individuals are prohibited from cutting the threatened indigenous species like *Cordia africana*, in both state and private forests. Utilizing products from within a state forest without a permit is punishable by between one and five years imprisonment as well as a fine of 10,000 Birr (USD 1,053)^[35]. In addition very few economic tree species such as *Cordia africana* are now managed by some farmers in their farmland as agroforestry tree and/or garden tree. This shows that such management and acquisition of economic benefits from species might promote local peoples' interest in conservation and maintenance of such locally important and threatened species^[14].

Conclusions

Cordia africana Lam. (Synonym: *Cordia abyssinica* R. Br.) is a tree (rarely shrubby) species. Its English common names are East African *Cordia* or large-leaved *Cordia* or Sudan teak. It grows in areas with altitudes between 550 and 2600 m a.s.l. It is a multipurpose tree species and it has good attributes as a good source of medicine, fodder, food and fuelwood. The wood is easy to work, and is used for making drums, beehives, household furniture and containers, and many other items. The species provides good bee forage. It is good planting the species to increase honey production. It is favored as a shade tree for coffee because of its short bole and occurs as a shade tree in coffee plantations; it is usually left in the fields, as it provides excellent shade for crops. It plays a great role in maintaining soil fertility and provide various products and services to the farmers. Thus, the continued use of this species in the agricultural setting of in the Ethiopian highlands needs to be focused. This is one of the most important timber trees in the flora area. It is the most preferred timber species and fetches high price at local market. Planting *Cordia africana* trees at wider spacing could enhance growth, but this practice still can be disadvantageous, because it increases the branch (knot) size and therefore has negative impact on stem quality. The demand for wood of *Cordia africana* by users of its timber and timber products is

enormous. This high demand has caused a rapid declining of the species, and the tree is now proclaimed as one of the most threatened species of Ethiopia in its natural habitat. *Cordia africana* is now managed by some farmers in their farmland as agroforestry tree and/or garden tree. This shows that such management of, and acquisition of economic benefits from species might promote local peoples' interest in conservation and maintenance of such locally important and endangered species.

References

1. Abbink J. Me'en Ritual, Medicinal and Other Plants: A contribution to South-west Ethiopian Ethno-Botany Journal of Ethiopian Studies. 1993; 26 (2):1-2
2. Abbink, J. Medicinal and Ritual Plants of the Ethiopian Southwest: An Account of Recent Research. Indigenous Knowledge and Development Monitor. 1995; 3(2):6-8.
3. Abdurhman N. Ethnobotanical Study of Medicinal Plants Used by Local People in Ofla Wereda, Southern Zone of Tigray Region, Ethiopia. M.Sc. Thesis. Addis Ababa, Ethiopia, 2010.
4. Abebe T, Holm S. Estimation of wood residues from small-scale commercial selective logging and sawmilling in tropical rain forests southwestern Ethiopia. International Forestry Review, 2003; 5(10):45-52.
5. Abebe T. Diversity in homegarden agroforestry systems of Southern Ethiopia, PhD thesis, Wageningen University, Wageningen, 2005.
6. Abera B. Plants used in material culture in Oromo community, Jimma, Southwest Oromia, Ethiopia. African Journal of Plant Science. 2013; 7(7):285-299.
7. Addis G, Asfaw Z, Woldu Z. Ethnobotany of Wild and Semi-wild Edible Plants of Konso Ethnic Community, South Ethiopia. Ethnobotany Research and Applications, 2013; 11:121-141.
8. Agidie A, Ayele B, Wassie A, Hadgu K, Aynekulu E, Mowo J. Agroforestry Practices and Farmers' Perception in Koga Water Shed, Upper Blue Nile Basin, Ethiopia, Agriculture and Forestry. 2013; 59(3):75-89.
9. Agize M, Demissew S, Asfaw Z. Ethnobotany of Medicinal Plants in Loma and Gena Bosa Districts (Weredas) of Dawro Zone, Southern Ethiopia. Journal of Herbal Medicine. 2013; 2(9):194-212.
10. Amenu E. Use and Management of Medicinal Plants by Indigenous People of Ejaji area (Chelya Wereda), West Shoa, Ethiopia: an Ethnobotanical Approach. M.Sc. Thesis. Addis Ababa University, 2007.
11. Amsalu N. Ethnobotanical Study of Medicinal Plants in Farta Wereda, South Gonder Zone of Amhara Region, Ethiopia. M.Sc. Thesis. Addis Ababa, Ethiopia, 2010.
12. Asfaw Z, Agren GI. Farmers' local knowledge and topsoil properties of agroforestry practices in Sidama, Southern Ethiopia. Agroforest Syst. 2007; 71:35-48.
13. Awas T, Demissew S. Ethnobotanical study of medicinal plants in Kafficho people, southwestern Ethiopia. In: Proceedings of the 16th International Conference of Ethiopian Studies, ed. by Svein Ege, Harald Aspen, Birhanu Teferra and Shiferaw Bekele, Trondheim, 2009.
14. Balemie K, Kebebew F. Ethnobotanical study of wild edible plants in Derashe and Kucha Districts, south Ethiopia, Journal of Ethnobiology and Ethnomedicine. 2006; 2:53.

15. Balemie K, Kelbessa E, Asfaw Z. Indigenous Medicinal Plant Utilization, Management and Threats in Fentalle Area, Eastern Shewa, Ethiopia. *Ethiopian Journal of Biological Science*. 2004; 3(1):37-58.
16. Barth RC. Influence of pinyon pine tree on soil chemical and physical properties. *Soil Sci. Soc. Am J*. 1980; 44:112-114.
17. Bekele M, Berhanu L. State of Forest Genetic Resources in Ethiopia. Sub-Regional workshop FAO/IPGRI/ICRAF on the conservation, management, sustainable utilization and enhancement of forest genetic resources in Sahelian and North- Sudanian Africa (Ouagadougou, Burkina Faso, 22-24 September 1998). Forest Genetic Resources Working Papers, Working Paper Forestry Department, FAO, Rome, 2001.
18. Bekele T, Haase G, Soromessa T. Forest Genetic Resources of Ethiopia: Status and Proposed Actions. In: Proceedings of the National Forest Genetic Resources Conservation Strategy Development Workshop (eds. Edwards, S., Abebe Demissie, Taye Bekele and Haase, G.), 1999, 39-46.
19. Bekele-Tesemma A. Useful trees and shrubs for Ethiopia: Identification, propagation and management for 17 Agro-climatic Zones. World Agro-forestry Center, Eastern Africa Region, Nairobi, Kenya, 2007, 550.
20. Birhane E, Aynekulu E, Mekuria W, Endale D. Management, use and ecology of medicinal plants in the degraded dry lands of Tigray, Northern Ethiopia. *Journal of Medicinal Plants Research*. 2011; 5(3):309-318.
21. Breitenbach FV. The Indigenous trees of Ethiopia. Second revised and enlarged edition, Ethiopian Forestry Association, Addis Ababa, 1963.
22. Bruce J. Select specimens of natural history, collected in travels to discover the source of the Nile, in Egypt, Arabia, Abyssinia and Nubia, Edinburgh, 1790, 3.
23. Bussmann RW, Swartzinsky P, Worede A, Evangelista P. Plant use in Odo-Bulu and Demaro, Bale Region, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2011; 7:28.
24. Carr GD. Boraginaceae. WWW.botany.hawaii.edu/faculty/carr/boragina.htm, 2006.
25. Carsan S. Sustainable Timber for small holder cropping System. unpublished Masters thesis, University of the Free State, South Africa, 2000.
26. Cartwright CR. The identification of wood used for nine taino artefacts in the british museum collections (unpublished research), 2010.
27. Chekole G. An Ethnobotanical Study of Plants Used in Traditional Medicine and as Wild Foods in and around Tara Gedam and Amba Remnant Forests in Libo Kemkem Wereda, South Gondar Zone, Amhara Region, Ethiopia. M.Sc. Thesis. Addis Ababa, Ethiopia, 2011.
28. Daniel TW, Helms JA, Baker FD. Principles of Silviculture. 2nd edition. McGraw-Hill. New York, USA, 1979, 500.
29. Deraro A. Genetic variation in *Cordia africana* Lam. in Ethiopia. Ph.D. Thesis. Georg-August-Universität Göttingen, Göttingen, 2007.
30. Deraro A, Bekele T, Näslund BÅ. Population structure and regeneration of woody species in a broad-leaved afro-montane rainforest in south-west Ethiopia. *Ethiopian Journal of Natural Resources*. 2003; 5(2):255-280.
31. EFAP (Ethiopian Forestry Action Program). Ministry of Natural Resources Development and Environmental Protection, Addis Ababa, Ethiopia, 1994.
32. Eggeling WJ, Dale IR. The indigenous trees of the Uganda Protectorate. Government Printer, Entebbe, Uganda, 1951, 491.
33. Ehete G. African Egalitarian Values and Indigenous Genres: The functional and Contextual Studies of Oromo Oral Literature in a Contemporary Perspective, 2009.
34. Etana B. Ethnobotanical Study of Tradational Medicinal Plants of Goma Wereda Jima Zone of Oromia Region, Ethiopia. M.Sc. Thesis. Addis Ababa, Ethiopia, 2010.
35. FDRE (Federal Democratic Republic of Ethiopia). Forest Development Conservation and Utilization Proclamation No. 542/2007. Addis Ababa, 2007.
36. Fichtl R, Adi A. Honeybee Flora of Ethiopia. Magraf Verlag, Germany, 1994, 510.
37. Friis I. Forests and Forest trees of Northeast Tropical Africa. Kew Bulletin Additional Series XV, Royal Botanical gardens, London, 1992, 396.
38. Getahun A. Some common medicinal and poisonous plants used in Ethiopian folk Medicine, Addis Ababa University, 1976, 3-63.
39. Gina T, Nigatu L, Animut G. Evaluation of potential yield and chemical composition of selected indigenous multi-purpose fodder trees in three districts of Wolayta Zone, Southern Ethiopia. *IDOSI Publications, World Appl Sci J*. 2014; 31(3):399-405.
40. Gindaba J, Rozanov A, Negash L. Response of seedlings of two Eucalyptus and three deciduous tree species from Ethiopia to severe water stress. *Forest Ecology and Management*, 2004; 201:119-129.
41. Gole T. Vegetation of the Yayu Forest in SW Ethiopia: impacts of human use and implications for in situ conservation of wild *Coffea arabica* L. populations. Ph.D. Thesis. University of Bonn, Germany, 2003.
42. Hailu T, Negash L, Olsson M. *Milletia ferruginea* from Southern Ethiopia: Impacts on soil fertility and growth of maize. *Agroforestry Systems*, 2000; 48:9-24.
43. ICRAF (International Centre for Research in Agroforestry). Agroforestry data base: *Cordia africana* Lam. ICRAF, 1998.
44. Ishengoma RC, Hamza KFS, Mosha S, Makonda FBS. Basic density and mechanical properties of *Cordia africana* Lam. grown in agroforestry in Moshi district, Tanzania. Proc. Of the Fourth International Conference on the Development of Wood Science, Wood Technology and Forestry, 14–16 July 1999, Misseneden Abbey, UK, 1999, 139-145.
45. Kahurananga J, Tadesse S, Bekele T. Informal Surveys to Assess Social Forestry at Dibandiba and Aleta Wendo, Ethiopia. *Agroforestry systems*, 1993; 24:57-80.
46. Lamprecht H. Silviculture in the tropics. Tropical forest ecosystems and their tree species possibilities and methods are the long-term utilization. T2-verlagsgeslls chaft, RoBdort, Germany, 1989, 296.
47. Lulekal E, Kelbessa E, Bekele T, Yiniger H. An ethnobotanical study of medicinal plants in Mana Angetu District, southeastern Ethiopia. *Journal of Ethnobiology and Ethnomedicine*, 2008.

48. Mehari A, Habte B. Influence of initial spacing on growth and branching characteristics of *Cordia africana* trees established on Eritrean highland. *New Forests*. 2006; 31:185-193.
49. Mesfin F, Demissew S, Teklehaymanot T. An ethnobotanical study of medicinal plants in Wonago Wereda, SNNPR, Ethiopia. *Journal of Ethnobiology and Ethnomedicine*. 2009; 5:28.
50. Mesfin K, Tekle G, Tesfay T. Ethnobotanical Study of Traditional Medicinal Plants Used by Indigenous People of Gemad District, Northern Ethiopia. *Journal of Medicinal Plants Studies*. 2013; 1(4):32-37.
51. Mwiinga RD, Kwesiga FR, Kamara CS. Decomposition of leaves of six multipurpose tree species in Chipata, Zambia. *For Ecol Manage*, 1994; 64:209-216.
52. Nair PKR. *An Introduction to Agroforestry*. Kluwer Academic Publishers, Dordrecht, 1993.
53. Negash L. *Indigenous Trees of Ethiopia: Biology, Uses and Propagation Techniques*. Printed by the SLU Reprocentralen, Umea, Sweden, 1995, 105-113.
54. Negash M. *Trees Management and Livelihoods in Gedeo's Agroforests, Ethiopia, Forests, Trees and Livelihoods*, 2007; 17(2):157-168.
55. Nosnitsin D. *Ethiopian Manuscripts and Ethiopian Manuscript Studies: a brief overview and evaluation*. In: "Comparative Oriental Manuscript Studies" (COMSt; <http://www1.uni-hamburg.de/COMST/>; member of team Cataloguing), 2012.
56. Nyberg, G, Hogberg P. Effects of young agroforestry trees on soils in on-farm situations in western Kenya. *Agroforestry Systems*, 1995; 32(1):45-52.
57. Obeng EA. *Cordia africana* Lam. In: Lemmens, R.H.M.J., Louppe, D. and Oteng-Amoako, A.A. (Editors). *PROTA (Plant Resources of Tropical Africa/Ressources végétales de l'Afrique tropicale)*, Wageningen, Netherlands, 2010. <http://www.prota4u.org/search.asp>.
58. Orwa C, Mutua A, Kindt R, Jamnadass R, Anthony S. *Agroforestry Database: a tree reference and selection guide version 4.0*. World Agroforestry Centre, Kenya, 2009.
59. PFE, (Pastoralist Forum Ethiopia) IIRR, (International Institute of Rural Reconstruction) and DF, (Developmental Fund). *Pastoralism and Land: Land tenure, administration and use in pastoral areas of Ethiopia*, 2010.
60. Regassa R. Diversity and conservation status of some economically valued indigenous medicinal plants in Hawassa College of Teacher Education Campus, Southern Ethiopia. *International Journal of Advanced Research*. 2013; 1(3):308-328.
61. Riedl H, Edwards S. *Gentianaceae to Cyclocheilaceae Flora of Ethiopia and Eritrea*, The National Herbarium, Addis Ababa University, Ethiopia and Uppsala, 2006, 5.
62. Schmitt CB. *Montane rainforest with wild Coffea arabica in the Bonga region (SW Ethiopia): plant diversity, wild coffee management and implications for conservation*. Ph.D. Thesis. Bonn, Germany, 2006.
63. Senbeta F. *Native Woody Species Regeneration under the Canopies of Tree Plantations at Munessa-Shashamane Forest Project Area, Southern Oromia, Ethiopia*. M.Sc. thesis. Swedish University, 1998.
64. Seta T, Demissew S, Asfaw Z. Home gardens of Wolayta, Southern Ethiopia: An ethnobotanical profile. *Academia Journal of Medicinal Plants*. 2013; 1(1):014-030.
65. Tamene B. *A Floristic Analysis and Ethnobotanical Study of the Semi- Wet Land of Cheffa Area, South Welo, Ethiopia*, M.Sc. Thesis, Addis Ababa, Ethiopia, 2000.
66. Teketay D. Tegineh. Shade trees of coffee in Hararghe, Eastern Ethiopia. *Int Tree Crop J*. 1991; 7:17-27.
67. Teklay A, Abera B, Giday M. An ethnobotanical study of medicinal plants used in Kilte Awulaelo District, Tigray Region of Ethiopia. *Journal of Ethnobiology and Ethnomedicine*. 2013; 9(65):2-23.
68. Teklay T, Malmer A. Decomposition of leaves from two indigenous trees of contrasting qualities under shaded-coffee and agricultural land-uses during the dry season at Wondo Genet, Ethiopia. *Soil Biol Biochem*. 2004; 36:777-786.
69. Teklay T, Nordgren A, Malmer A. Soil respiration characteristics of tropical soils from agricultural and forestry land-uses at Wondo Genet (Ethiopia) in response to C, N and P amendments. *Soil Biology and Biochemistry*. 2006; 38(1):125-133.
70. Teklehaymanot T, Giday M. Ethnobotanical study of wild edible plants of Kara and Kwegu semi-pastoralist people in Lower Omo River Valley, Debub Omo Zone. SNNPR, Ethiopia. *J Ethnobiol and Ethnomed*. 2010; 6:23.
71. Tewolde-Berhan S, Fagertun RS, Abegaz K, Judith N, Abay F, Trude W. Ferric Reducing Antioxidant Power and Total Phenols in *Cordia africana*. *African Journal of Biochemistry Research*. 2013; 7(11):215-224.
72. Tiruneh Fentahun M, Hager H. Exploiting locally available resources for food and nutritional security enhancement: wild fruits diversity, potential and state of exploitation in the Amhara region of Ethiopia. *Food Sec*. 2009; 1:207-219.
73. Vetaas OR. Micro-site effects of trees and shrubs in dry savannas. *J Veg Sci*. 1992; 3:337-344.
74. Warfa AM. *Cordia (Boraginaceae) in NE Tropical Africa and Tropical Arabia*. Ph.D. Thesis, Uppsala University, 1988, 78.
75. Wassie A. *Opportunities, constraints and prospects of Ethiopian Orthodox Tewahdo Church in conserving forest resources*. M.Sc. Thesis. Faculty of Forestry, Swedish University of Agricultural Sciences, Sweden, 2004, 70.
76. Yadessa A, Bekere D. Influence of scattered *Cordia africana* trees on maize yield in western Oromia, Ethiopia. *Proc. 4th Forestry Society of Ethiopia (FSE) conference 2002*, 91-98.
77. Yadessa A, Itana F, Olsson M. Contribution of indigenous trees to soil properties: the case of scattered trees of *Cordia africana* Lam. in croplands of western Oromia. *EJNR*. 2001; 3(2):245-270.
78. Yirdaw E. Diversity of naturally regenerated native woody species in forest plantations in the Ethiopian highlands. *New Forests*, 2001; 22(1):159-177.
79. Yirdaw E, Leinonen K. Seed germination responses of four afro-montane tree species to red/farred ratio and

- temperature. *Forest Ecology and Management*. 2002; 168 (3):53-61.
80. Yirga G. Assessment of indigenous knowledge of medicinal plants in Central Zone of Tigray, Northern Ethiopia *African. Journal of Plant Science*. 2010; 4(1):006-011.
 81. Young A. *Agroforestry for soil management*. Second Edition. CAB International, UK, 1997, 71.
 82. Zinke PJ. The pattern of influence of individual forest trees on soil properties. *Ecology*, 1962; 43:30-133.