MNYORORO WA THAMANI WA MAZAO YA MISITU

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UTILIZATION POTENTIAL OF LESSER-KNOWN TIMBER SPECIES FROM MIOMBO FORESTS IN TANGA, LINDI AND RUVUMA REGIONS

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UTILIZATION POTENTIAL OF LESSER-KNOWN TIMBER SPECIES FROM MIOMBO FORESTS IN TANGA, LINDI AND RUVUMA REGIONS



FINAL REPORT

Research Report of the Lesser-Known Timber Species Study Submitted to the Forestry and Value Chains Development Programme (FORVAC)

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1.1 Background and justification

1.1.1 Tanzanian timber market situation

Tanzania is endowed with a number of vegetation types, ranging from humid tropical forests with amount of annual rainfall exceeding 3,500 mm, to arid semi-deserts receiving less than 350 mm of rainfall per year. However, the country is experiencing the highest global deforestation rate averaging 2% (URT, 1998).

The estimated current human population of Tanzania is 62 million, based on projections of the latest United Nations data, with over 80% of this population still living in rural areas. The human growth rate is projected to 3%, being the highest in the world (Agwanda and Amani, 2014).

With such a human population living in the rural areas, the people have few feasible alternatives to exploit the forests and forest resources. The Tanzanian government and other Non-Governmental Organizations have to realize that intervention is needed to limit the rampant destruction of the forests and at the same time improving the livelihood of the citizens. The timber stakeholders need alternatives and the national economies need better ways to derive value from the remaining forests in order to maintain their many useful but under-valued functions. One option to this is increasing utilization and market promotion of lesser-known and therefore, the lesser-utilized timber species which are still plenty and available in those forest areas.

Conversely, the Tanzanian timber market is dominated by a small number of commercially well-known timber species. The country has more than 700 indigenous wood species ranging from low to high densities and out of these species, only a handful (about 20 species) of well-known tree species are utilized commercially, and often for purposes which other known but equally suitable and cheaper timber species could be used (Ishengoma *et al*, 1998). These species include e.g., *Pterocarpus angolensis* (mninga), *Milicia excelsa* (mvule), *Dalbergia melanoxylon* (mpingo), *Ocotea usambarensis* (mkemfa) and *Khaya anthotheca* (mkangazi). Many of the other timber species in the country are lesser known to users and therefore lesser utilized. They are mainly used by traditional timber users, locally. Since properties of these lesser-known and lesser-utilized timber species are not known, it is difficult to promote them in national and international markets.

Apart from many timber species being not known by users, the properties and technical information on important timber species utilized in different part of the country is not documented, and therefore not available to users. Lack of such technical information does not only hinder economical and rational utilization, but also market promotion (Makonda *et al.*, 2016a; 2016b).

This has resulted into over concentration on few well-known timber species, and consequently to over exploitation. Following this malpractice, immature trees with inferior properties are now being cut to temporarily meet the market demand (Ishengoma *et al.*, 1997). If more is known on the properties of lesser-known and lesser-utilized timber species, some of these species could be found suitable and therefore reduce pressure on the well-known timber species, also contributing to local economy, particularly to the Village Land Forest Reserves (VLFRs) with proper forest management plans.

For timber to penetrate the markets, a suitable marketing strategy, involving promotion, needs to be developed. Successful market promotion among other things is backed by full information of timber species. Therefore, information on physical, mechanical and other timber processing properties and potential uses needs to be known. Equally available merchantable volume must be big enough to justify market promotion and investments. All these call for extensive research work to determine and document the properties of most lesser-known and lesser-utilized timber species and formulate strategies for market promotion of timber species that will be identified to be suitable.

1.1.2 FORVAC interventions

Forestry and Value Chains Development (FORVAC) is a 4-year (201 8-2022) joint development cooperation programme funded by the Ministry for Foreign Affairs of Finland (MFA Finland) and implemented under the Ministry of Natural Resources and Tourism of Tanzania. It aims to contribute to increased economic, social and environmental benefits from forests and woodlands.

Timber inventories in Tanzanian forests by the National Forest Resources Monitoring and Assessment of Tanzania Mainland (NAFORMA) and respective local governments have revealed rich amount of lesser-known timber species (MNRT, 2015, FORVAC, 2019) hence a need to research on their technical properties and promote them equally, hand in hand with the well-known timber species. Correspondingly, in June 2020, FORVAC extended its support to cover establishment of a miombo timber species database and identification and testing of lesser-known tree species, with an objective to contribute to CBFM communities' income and increased market through

promoting wide range of Tanzanian miombo timber species and the following scope:

1) Establish an open-access database / website and related catalogue available for wider audience listing all studied miombo timber species: names (scientific, trade name, vernacular names), wood characteristics, high quality photos, any additional information necessary; and
2) Identify, test and add 10-15 additional lesser-known species, which have potential in terms of increasing market for Tanzanian Community Timber, in the above-mentioned database.

The work was funded by FORVAC and conducted by FORCONSULT through the Department of Forest Engineering and Wood Sciences (DFEWS), in the College of Forestry, Wildlife and Tourism (CFWT) at Sokoine University of Agriculture (SUA) in Morogoro.

1.2 Objectives of the lesser-known timber species study

This work intended to unveil all important technical information on 14 identified lesser-known timber species in the FORVAC clusters to the attention of timber users. It is important that this information is made public and accessible to those engaged in the timber industry, not only to increase the resource base, but also contributing to reduction of both poverty and the current pressure on the commercial timbers of Tanzania.

DFEWS was selected to implement the following three components of this process:

i) Establishment of a Miombo Timber Species Database;
ii) Collecting all available information on miombo species wood characteristics and photos in a form, which is readily accessible for wider audience (database/website and related catalogue); and
iii) Identifying and testing 10 - 15 lesser-known miombo timber species and adding them into the database (research of lesser-known timber species).

This document is a research report of the lesser timber species study conducted by DFEWS in 2020 – 2021.

To achieve the objective of the assignment, the following inputs were worked out:

- Identification of the 14 lesser-known timber species in the FORVAC working areas in three clusters covered by the programme, namely Tanga, Lindi and Ruvuma; and
- Determining and documenting technical properties of the selected lesser-known timber species. The technical properties were determined through laboratory testing, covering the following:

- Physical properties: colour, figure, moisture content and basic density;
- Anatomical properties;
- Mechanical properties;
- Machining and peeling characteristics;
- Drying characteristics; and
- Finishing characteristics.

2 METHODOLOGY

2.1 Activities by objectives and scope

2.1.1 Determination of technical properties

The technical properties of the 14 lesser-known timber species were determined and documented.

These species are: *Brachystegia allennii, Brachystegia floribunda, Brachystegia glaberrima, Brachystegia utilis* and *Burkea africana*. Others are *Diospyros zombensis, Erythrophleum africanum, Lannea schweinfurthii, Lonchocarpus bussei* and *Pseudolachnostylis maprouneifolia*. The other species are *Pteleopsis myrtifolia, Sclerocarya birrea, Toona ciliata* and *Vitex doniana*. In Table 1, the vernacular names of the species have been listed.

The determination and documentation of the properties encompassed the following activities:

- Desk study to acquaint with type of timber resources available in the study areas and separation of well-known/utilized species from lesser-known/utilized species, employing information available in "Commercial Timbers of Tanzania" (Bryce 1967, revised in 2000) and results of the studies implemented in Tanzania between 2000 and 2020. Also, Forest Management Plans developed in the FORVAC clusters were critically reviewed to unveil the available potential species. Moreover, literature reviews accompanied with botanical and tentative technical aspects were employed;

- Field botanical survey to verify and identify the availability of these species;

- Collection of test samples, description of the site characteristics of the species and transportation of the specimens to the Department of Forest Engineering and Wood Sciences Laboratory, at SUA Morogoro;

- Specimen preparation including sawing to size and air drying in which some of the machining and drying characteristics were determined;

- Oven drying from green state to determine air dry density according to Vieilledent *et al*. (2018), drying characteristics and colour;

- Machining by sanding, mortising, moulding, gluing, nailing, polishing to determine the machining and finishing characteristics;

- Testing samples on Monsanto Tensometer to determine the mechanical properties, which include: (a) Static bending (Modulus of Elasticity, Modulus of Rupture, Work to maximum Load and Total Work) (b) Impact bending (c) Compression parallel to grain (d) Shear (e) Cleavage stress; and

- Laboratory analysis of the anatomical properties using naked eyes, hand lenses, micro-projectors and microscopes.

2.1.2 Identification of suitable species and cataloguing

Based on the above activities and results, identification of suitable species for particular end-uses and development of a catalogue containing timber utilization technical data were made. Similar species in the above properties for the lesser-known/utilized and the well-known/utilized species were grouped together to facilitate marketing of these species. This was done by defining the properties required for a particular end-use and select the species with those properties.

Eventually the lesser-known timber species study focused on 14 species (Table 1).

2.2 Brief description of the study areas

The Forestry and Value Chains Development Programme (FORVAC) is working in a total number of 12 districts in three different cluster areas, Tanga, Lindi and Ruvuma named in accordance with the correspondent regions of Tanzania. These are among the poorest districts of Tanzania though they are endowed with vast natural resources in terms of forests. Forest inventories in these areas by the National Forest Resources Monitoring and Assessment of Tanzania Mainland (NAFORMA) and respective local governments have revealed rich amount of lesser-known timber species (MNRT, 2015, FORVAC, 2019) hence a need to research on their technical properties and promote them equally, hand in hand with the well-known timber species.

This study covered the Village Land Forest Reserves (VLFRs) in the three FORVAC operational clusters of Tanga, Lindi and Ruvuma in a total of 12 districts as follows:

- Tanga cluster: Handeni and Kilindi districts in Tanga Region, Mpwapwa District in Dodoma Region and Suledo Community Forest in Kiteto District in Manyara Region;
- Lindi cluster: Districts of Liwale, Ruangwa and Nachingwea; and
- Ruvuma cluster: Districts of Namtumbo, Mbinga, Songea, Nyasa and Tunduru.

Table 1 A summary of information for sampling of lesser-known timber species under FORVAC operational clusters in the selected Village Land Forest Reserves (VLFRs) in Tanzania

Location (village, district)	VLFR	Species Name	
		Vernacular	Scientific
Kwedikabu, Handeni	Kwedikabu	Mtondolo (Zigua)	*Brachystegia floribunda*
Kitumbi, Handeni	Kitumbi	Mtundu (Zigua)	*Brachystegia utilis*
		Myombo (Zigua)	*Brachystegia glaberrima*
Namatunu, Nachingwea	Nakambenga	Muhumbuti (Ngindo, Mwera)	*Brachystegia allennii*
Kiegei B, Nachingwea	Nakalola	Mpuga (Ngindo), Mkarati (Swahili)	*Burkea africana*
		Mpimbalati (Ngindo), Nchenjele (Konde), Mkalati (Swahili)	*Erythrophleum africanum*
		Mpweke (Ngindo)	*Diospyros zombensis*
		Mpome (Ngindo)	*Lannea schweinfurthii*
		Kimbulei Kikulu (Ngindo), Chimbulele (Mwera)	*Lonchocarpus bussei*
		Mgongo (Mwera), Mngóngo Pori (Swahili)	*Sclerocarya birrea*
Mtungunyu, Liwale	Nabete	Msolo, Mneke, Muholo (Ngindo, Tengo, Ngoni)	*Pseudolachnostylis maprouneifolia*
Nangano, Liwale	Unguungu	Mwindi/Mnepa	*Pteleopsis myrtifolia*
Kitulo, Songea	Lupangalo	Msedelera	*Toona ciliata*
		Mpitimbi/Mpindimbi (Ngoni, Tengo)	*Vitex doniana*

Almost all of these forests occur in areas with similar ecological, cultural and socioeconomic characteristics. The land uses mainly comprise of subsistence agriculture both shifting and on permanent plots. The main crops grown are cassava, maize and rice in Tanga and cashewnut, cassava, maize and peas in Lindi and Ruvuma.

2.3 Sampling and data collection

The wood samples were collected from three mature and defect free trees of each 14 lesser-known and lesser-utilized timber species identified. The sample trees were randomly selected after thorough observation of their physical appearance. The trees represented small, medium and large sizes. The trees were felled and by using caliper and a measuring tape, diameter at breast height (dbh) and total tree height were measured respectively, and recorded. Three logs of 1.5 m length were cut from breast height upwards and marked from each tree felled. The logs (billets) were hauled to nearby sawmills, sawn to cants before being transported to the Department of Wood Utilization, Sokoine University of Agriculture for further processing. The cants were then re-sawn into 30 mm x 65 mm x 1,500 mm planks from the pith left and right towards the bark. The planks were numbered and labelled sequentially to show the position of extraction from the tree and direction of sawing and stacked for drying until the moisture contents became lower than 15%.

The scantlings were further planed down to 20 mm x 20 mm x 1,500 mm from which various dimensions of different test samples were extracted as shown in Table 2.

Table 2 Wood test samples for strength properties

Type of test	Test sample size (mm)
Static bending	20 x 20 x 300
Impact bending	20 x 20 x 300
Compression parallel to grain	20 x 20 x 60
Hardness	20 x 20 x 60
Shear parallel to the grain	20 x 20 x 20
Cleavage parallel to the grain	20 x 20 x 45

Determination of moisture content of the samples for this study was done according to Desch (1981) using oven dry method. Different mechanical and anatomical properties, natural durability, seasoning and chemical treatability tests were carried out following the procedures described by BS 373 (1957; 1976), Lavers (1969), Panshin and de Zeeuw (1970), ISO 3130 and ISO 3133 (1975).

2.4 Data analysis and interpretation

The obtained data were summarized and subjected to Excel Computer packages for analysis employing mostly, descriptive statistics.

2.5 Presentation of important findings

The technical properties of the studied lesser-known and lesser-utilized timber species are presented in Chapter 3. For each timber, there is species identity given in botanical, family, trade and local names. For the botanical names, synonyms have also been included. The trade and local names are those commonly used in Tanzania.

The abbreviations used for the local names are as follows:

Eng:	English
Mako:	Makonde
Matum:	Matumbi
Mwer:	Mwera
Ngind:	Ngindo
Swah:	Swahili
Zig:	Zigua

After the species identity, properties of each species are given including tree description accompanied by a photograph of the tree portraying its form, geographical distribution and the technical suitability of the wood under different treatments. A photograph of a timber specimen portraying both polished and unpolished finished surfaces is given. At the end for each species, there is a highlight of recommended uses, both wood and non-wood.

A glossary on the important properties of wood has been attached as Annex I and the key for these properties is presented in Annex II.

3 RESULTS

3.1 *Brachystegia allennii* (Muhumbuti)

SPECIES IDENTITY

Botanical name: *Brachystegia allennii* Hutch. & Burtt Davy
Synonym: *Brachystegia giorgii* De Wild.
Brachystegia pruinosa De Wild.
Brachystegia schliebenii Harms.

Family name: Fabaceae sub-family Mimosaaceae

Trade name: Muhumbuti

Local names: **Mwer:** Muhumbuti **Ngind:** Kapepe **Eng:** Escarpment brachystegia

PROPERTIES

Tree description: Is a medium-sized deciduous tree, growing to between 3 - 15 m high, occasionally to 20 m with dbh reaching 50 cm. In the study areas, trees had an average height of 19 m and dbh of 37 cm. The bark is grey, rough, more or less deeply fissured vertically and cracked horizontally.

Plate 1 **Photograph of *Brachystegia allennii*** tree

Distribution: *Brachystegia allennii* is a deciduous tree with a rounded crown. It is native to D.R. Congo, Tanzania, Malawi, Mozambique, Zambia and Zimbabwe occurring on stony hill sides in dry deciduous woodland at an altitudinal range of 500 to 1400 m.a.s.l. In general, it is locally dominant on well drained sites.
In Tanzania, the largest concentrations are found in the Southern parts and the species is fairly available in Lindi and Ruvuma clusters.

The wood:

Physical properties
Sapwood: White to yellow
Heartwood: Dark brown or red-brown, with fine white streaks. The wood is fairly heavy with medium, wavy to fine texture, interlocked grain and a subdued partridge figure on tangential surfaces.
Sapwood-Heartwood ratio: 42:58
Basic density: 587 kg/m^3
Air dry density: 709 kg/m^3

Strength properties

- Static bending – centre loading	
Modulus of Rupture:	102.7 N/mm^2
Modulus of elasticity:	10,572 N/mm^2
Work to maximum load:	0.27 mmN/mm^3
Total work:	0.33 mmN/mm^3
- Impact bending:	1.05 m
- Compression // to grain:	41.3 N/mm^2
- Hardness:	3,565 N
- Shear:	12.1 N/mm^2
- Cleavage:	R = 16.6 N/mm width
	T = 28.7 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics
The wood air-dries slowly and does not show surface checking and is stable in service. Shrinkage rates are 1.5% radial and 2.0% tangential from green to 12% moisture content. Movement is classified as small with 1.2% and 1.3% in the radial and tangential directions, respectively.

Machining and finishing characteristics
The wood is easy to saw and work and can be finished to an excellent surface except where the grain is strongly interlocked. The timber has good gluing and

nailing properties so pre-boring is not necessary for screws and nails.

Anatomical features
The grain is wavy or straight, sometimes slightly interlocked, texture fine and even.
Growth rings: Present.
Vessels: moderately small to medium-sized, solitary and in radial groups of two or more, and clusters, perforations simple abundant.
Density: more than 25 per sq. mm (numerous).
Size: Less than 0.05 mm (minute, not visible to the naked eye).
Gum deposits: Present.
Parenchyma tissue: Abundant, paratracheal, aliform and confluent also scattered diffuse and irregular terminal lines.
Ray tissue: Arrangement: homocellular, indistinct to the naked eyes.
Density: 10 per mm.
Size: Less than 0.03 mm (very fine).

Radial **Tangential**
Plate 2 ***Brachystegia allennii* timber**

RECOMMENDED USES

Wood

Brachystegia allennii is excellent for joinery and furniture, suitable for situations where there are wide variations in humidity. It also has good fuelwood and charcoal qualities.

Non-wood

The species is nitrogen-fixing, used for bee-hive and also important shade tree. Elsewhere, it is reported that the tree is harvested from the wild for local use of its bark in making river crafts.

3.2 *Brachystegia floribunda* (Mtondolo)

SPECIES IDENTITY

Botanical name: *Brachystegia floribunda* Benth.

Synonyms: *Brachystegia nchangensis* Greenway
Brachystegia polyantha Harms.

Family name: Fabaceae sub-family Mimosaaceae

Trade name: Mtondolo

Local names: **Zig:** Mtondolo **Swah:** Mtondolo

PROPERTIES

Tree description:

Brachystegia floribunda is usually a small deciduous tree, growing up to 18 m tall and 70 cm in diameter. In the study areas, the trees had an average height of 28 m and dbh of 55 cm. The outer bark is grey, shallowly fissured longitudinally or dark coarsely reticulated, flaking in thick rectangular scales. The inner bark is reddish. The crown is thin at first, narrow, erect-branched, spreading and irregularly rounded.

Plate 3 Photograph of *Brachystegia floribunda* tree

Distribution: *Brachystegia floribunda* is native to and distributed in DR Congo, Tanzania, Malawi, Zambia, Angola and Mozambique, occurring between 700 to 2,100 m.a.s.l.

in deciduous woodlands. Usually, it prefers an average annual rainfall above 1,000 mm. It is locally abundant, usually dominant and often in pure stands, or co-dominant with *Brachystegia spiciformis, B. longifolia* and *Julbernardia paniculata*.

The wood:

Physical properties

Sapwood: Yellowish

Heartwood: Reddish-brown with bands variable in colour from yellow to dark brown. The texture is fine.

Sapwood-Heartwood ratio: 41:59

Basic density: 506 kg/m^3

Air dry density: 611 kg/m^3

Strength properties

- Static bending – centre loading

Modulus of Rupture:	96.0 N/mm^2
Modulus of elasticity:	8,188 N/mm^2
Work to maximum load:	0.27 mm N/mm^3
Total work:	0.31 mm N/mm^3
- Impact bending:	1.05 m
- **Compression // to grain:**	33.5 N/mm^2
- Hardness:	3,488 N
- Shear:	9.9 N/mm^2
- Cleavage:	R = 13.4 N/mm width
	T = 25.3 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics

The timber dries very slowly with appreciable surface checking and some distortion and end-splitting. Shrinkage from green to 12% moisture content; radial 2.1% and tangential 4.3%, Movement is classified as medium with radial movement 1.3% and tangential movement 2.8%.

Machining and finishing characteristics

Difficult to saw and machine and causes moderate blunting of knives and cutters due to the interlocked grain which liable to tear in planing unless the cutting angle is adjusted to 10^o. Bending is very poor, veneer peeling requires high power and very hard on the knife.

The species moulds poorly with rough and patchy surfaces. The timber is difficult to nail and cannot be screwed without drilling.

Anatomical features
Growth rings: rings distinct and are marked by narrow bands of terminal parenchyma.
Vessels: Arrangement: mostly solitary, a few in radial groups of 2 – 4, perforations simple.
Density: 3 - 4 per sq. mm (numerous).
Size: 0.1 mm to 0.3 mm (moderately large, visible to the naked eye).
Gum deposits: Abundant.
Parenchyma tissue: Distinct to the naked eye, vasicentric, confluent where the vessels are close together, terminal prominent.
Rays tissue: Arrangement: homocellular, storeyed.
Density: 14 to 16 per sq. mm (numerous).
Size: Less than 0.03 mm (very fine).

Radial Tangential

Plate 4 *Brachystegia floribunda* timber

RECOMMENDED USES

Wood

The wood of *Brachystegia floribunda* can be used for poles, rafters, planks, tool handles and mine props. However, the durability of the wood is reported as low (Brink, 2010). The wood can also be used as fuelwood and for making charcoal.

Non-wood

The inner bark of the tree is harvested yielding fibre that is used for lashings. The tree is browsed by livestock and is a source of feed for bees and edible caterpillars. In traditional medicine, a leaf infusion is used for the treatment of eye problems.

3.3 *Brachystegia glaberrima* (Mtondolo)

SPECIES IDENTITY

Botanical name: *Brachystegia glaberrima* R.E.Fr.

Synonyms: *Brachystegia longifolia* Benth.
Brachystegia boumei Greenway

Family name: Fabaceae sub-family Mimosaceae

Trade name: Mtondolo

Local names: **Zig:** Myombo **Swah:** Mtondolo

PROPERTIES

Tree description: *Brachystegia glaberrima* is a small tree growing up to 18 m height and 70 cm dbh. In the study areas, the trees had an average height of 23 m and dbh of 45 cm. The bole often has conspicuous rounded bosses with rough bark which has few long deep furrows and grey in colour. The crown is ovoid, becoming flattish only in age with main branches being sub-erect accompanied by many branchlets. The foliage is evenly spreading in all directions.

Plate 5 **Photograph of *Brachystegia glaberrima* tree**

Distribution: *Brachystegia glaberrima* is native to and distributed in Congo Republic, D.R. Congo, Tanzania, Zambia, Angola, Malawi and Mozambique. It prefers altitudinal range of 840 to 1,500 m.a.s.l.

The wood:

Physical properties
Sapwood: Greyish-white
Heartwood: Reddish to dark-brown
Sapwood-Heartwood ratio: 32:68
Basic density: 522 kg/m^3
Air dry density: 630 kg/m^3

Strength properties
- Static bending – centre loading

Modulus of Rupture:	109.4 N/mm^2
Modulus of elasticity:	8,885 N/mm^2
Work to maximum load:	0.28 mmN/mm^3
Total work:	0.35 mmN/mm^3
- Impact bending:	1.03 m
- Compression // to grain:	35.0 N/mm^2
- Hardness:	3,658 N
- Shear:	10.8 N/mm^2
- Cleavage:	R = 15.8 N/mm width
	T = 32.2 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics
Dries fairly slowly and has tendency to surface checking.

Shrinkage from green to 12% moisture content; radial 2% and tangential 2.9%, Movement is classified as small with radial movement 1.1% and tangential movement 1.1%.

Machining characteristics
Works well by machine but hard to work with hand tools.

Finishing characteristics
The species moulds cleanly and sands easily to an excellent finish**.** The timber is difficult to glue and is very difficult to nail.

Anatomical features
Growth rings: rings are distinct and are marked by pore clusters at the start of the ring and a darker zone with fibres predominating at the end of the ring.
Vessels: Arrangement; radial multiples and also radial oblique.
Density: more than 250 per 10 sq. mm (numerous).

Size: Less than 0.05 mm (minute, not visible to the naked eye).
Gum deposits: Present.
Parenchyma tissue: Indistinct, sparse, apotracheal.
Ray tissue: Arrangement: storied.
Density: More than 50 per 5 sq. mm.
Size: Less than 0.05 mm (fine).

Radial **Tangential**

Plate 6 ***Brachystegia glaberrima*** **timber**

RECOMMENDED USES

Wood

Though considered inferior, the timber from *Brachystegia glaberrima* is suitable for general purposes including furniture and joinery, and the wood suits uses as poles, posts and fuel.

Non-wood

The species is nitrogen-fixing, important shade tree, used for beehives, leaves provide fodder and mulch. Used in several medicinal applications: roots treat dysentery and stomach problems. The fibrous bark has been used to make traditional garments and cordages.

3.4 *Brachystegia utilis* (Mtundu)

SPECIES IDENTITY

Botanical name: *Brachystegia utilis* Hutch. & Burtt Davy

Synonyms: *Brachystegia diloloensis* De Wild.

Family name: Fabaceae sub-family Mimosaceae

Trade name: Mtundu

Local names: **Swah**: Mtundu; **Zig:** Mtundu; **Eng:** bean-pod tree

PROPERTIES

Tree description: *Brachystegia utilis* is a medium to large-sized tree growing up to 25 m in height and 60 cm in dbh. In the study areas, the trees had an average height of 20 m and dbh of 47 cm. The tree has a flat crown and the bark is dark brown or pale grey, smooth when young and turns rough later. The bark slash is bright green in the outer layers, yellow and fibrous in the inner. Branches are heavy, often twisting and curving.

Plate 7 Photograph of *Brachystegia utilis* tree

Distribution: *Brachystegia utilis* is native to Tropical Africa in Tanzania, eastern Angola, southern D.R. Congo, Zambia, Malawi, Mozambique and Zimbabwe. It occurs in deciduous woodlands, locally dominant or co-dominant typically in zones or groups on ridges, scarps and slopes, notably in shallow, stony or gritty soils over granite at altitudes ranging from 300 to 1,830 m.a.s.l.

In Tanzania, *Brachystegia utilis* is reported to have fair occurrence in Handeni, Sumbawanga, Singida, Kondoa and Lindi districts. The species can be propagated easily however, trees are rather slow growing. Seeds are best planted in situ, germinate readily but seedlings are difficult to transplant.

The wood:

Physical properties

Sapwood: Pale cream to white

Heartwood: Variable in colour from pale brown, pale reddish-brown, yellowish-brown to dark brown. It has strongly interlocked grain and uneven medium to coarse texture. Butt rot in over-mature trees and large borer tunnels in the heartwood are common.

Sapwood-Heartwood ratio: 23:77

Basic density: 560 kg/m^3

Air dry density: 676 kg/m^3

Strength properties

Static bending – centre loading

Modulus of Rupture:	79.8 N/mm^2
Modulus of elasticity:	11,242 N/mm^2
Work to maximum load:	0.31 mmN/mm^3
Total work:	0.36 mmN/mm^3
- Impact bending:	1.06 m
- Compression // to grain:	36.6 N/mm^2
- Hardness:	4,236 N
- Shear:	11.9 N/mm^2
- Cleavage:	R = 15.6 N/mm width
	T = 20.1 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics
The timber dries very slowly with appreciable surface checking and some distortion and end-splitting. Shrinkage from green to 12% moisture content; radial 3.1% and tangential 4.2%, Movement is classified as medium with radial movement 1.7% and tangential movement 2.5%.

Machining and finishing characteristics
Ring shakes are common during felling. The wood is difficult to saw and machine and causes moderate blunting of knives and cutters due to the interlocked grain which liable to tear in planing unless the cutting angle is adjusted to 10^{o}. Bending is very poor, veneer peeling requires high power and very hard on the knife. The species moulds poorly with rough and patchy surfaces**.** The timber is difficult to nail and cannot be screwed without drilling.

Anatomical features
Growth rings: rings distinct and are marked by narrow bands of terminal parenchyma.
Vessels: Arrangement: mostly solitary, a few in radial groups of 2 – 4, perforations simple.
Density: 3 - 4 per sq. mm (numerous).
Size: 0.1 mm to 0.3 mm (moderately large, visible to the naked eye).
Gum deposits: Abundant.
Parenchyma tissue: Distinct to the naked eye, vasicentric, confluent where the vessels are close together, terminal prominent.
Rays tissue: Arrangement: homocellular, storeyed.
Density: 14 to 16 per sq. mm (numerous).
Size: Less than 0.03 mm (very fine).

Radial **Tangential**

Plate 8 ***Brachystegia utilis* timber**

RECOMMENDED USES

Wood

The timber is suitable for boats and general construction though a rather inferior general-purpose timber. Tools handles, ladders, railway sleepers, cheap furniture and shuttering. It is also excellent for fuelwood and charcoal.

Non-wood

The species is nitrogen-fixing, important shade tree, used for beehives, leaves provide fodder and mulch. Used in several medicinal applications: roots treat dysentery and stomach problems. The fibrous bark has been used to make traditional garments and string.

3.5 *Burkea africana* (Mkarati)

SPECIES IDENTITY

Botanical name: *Burkea africana Hook.*

Synonyms: None

Family name: Fabaceae subfamily: Caesalpinaceae

Trade name: Mkarati

Local names: **Ngind:** Mpuga **Swah**: Mkarati **Eng:** Wild syringa tree

PROPERTIES

Tree description: *Burkea africana* is a small to medium-sized deciduous tree growing up to 20 m tall and up to 80 cm in dbh. In this study, trees had an average height of 23 m and dbh of 41 cm. The bark surface is scaly and fissured, grey to dark greyish brown in colour, the inner bark being fibrous, pink to dull red or purplish brown. The crown is open, often flat with spreading branches. When not in bloom, *Burkea africana* is often confused with *Erythrophleum africanum* (Welw. ex Benth.) Harms and *Albizia antunesiana* Harms, but it differs from both by its reddish brown velvety hairy young growing tips of twigs. *Burkea africana* is difficult to cultivate, seeds may germinate in 10 days to six months and often at a low rate.

Plate 9 Photograph of *Burkea africana* tree

Distribution: *Burkea africana* is native and widely distributed in tropical Africa southwards to Namibia, Botswana and South Africa. It is a common and characteristic tree of sandy soils in dry deciduous woodlands and wooded savanna between 50 to 1,750 m.a.s.l. The annual rainfall in its area of distribution is 1,000 to1,200 mm. It is often associated with *Terminalia sericea* Burch. ex DC. and *Ochna pulchra* Hook.f.

The wood:

Physical properties

Sapwood: Yellowish or pinkish white

Heartwood: Brown with grey and green tinges, turning reddish brown or dark brown upon exposure. The grain is interlocked or wavy, texture fine to moderately fine and even. The wood is lustrous and displays a nice stripe figure.

Sapwood-Heartwood ratio: 16:84

Basic density: 956 kg/m^3

Air dry density: 1,155 kg/m^3.

Strength properties

- Static bending – centre loading

Modulus of Rupture:	112.3 N/mm^2
Modulus of elasticity:	14,196 N/mm^2
Work to maximum load:	0.41 mmN/mm^3
Total work:	0.56 mmN/mm^3
- Impact bending:	1.21 m
- Compression // to grain:	62.6 N/mm^2
- Hardness:	7,610 N
- Shear:	21.5 N/mm^2
- Cleavage:	R = 17.5 N/mm width
	T = 93.3 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics

The timber air dries moderately fast, with little tendency to corrugate, split or distort. The rates of shrinkage are moderate, from green to oven dry 3.6% radial and 5.2% tangential. Once dry, the wood is stable in service with radial movement of 1.0% and tangential 1.1%.

Machining and finishing characteristics

Although the wood is very heavy, it is easy to saw and turn, but difficult to work with other hand tools. The presence of interlocked grain makes the wood

susceptible to tearing in planing operations. The wood has good gluing and finishing properties. However, it is liable to splitting upon nailing, therefore pre-boring is recommended.

Anatomical features
Growth rings: Boundaries indistinct or absent.
Vessels: Arrangement; evenly distributed, mostly solitary but with some radial multiples up to 5, perforations simple.
Density: 5 – 20 vessels per mm^2.
Size: 0.1 mm to 0.3 mm (moderately large, visible to the naked eye).
Gum deposits: Abundant.
Parenchyma tissue: Indistinct, sparse, apotracheal.
Rays tissue: Arrangement: homocellular, storeyed, distinct to the naked eyes, terminal, vasicentric and aliform, occasionally confluent.
Density: 4 to 12 rays per mm.
Size: Less than 0.05 mm (fine).

Radial **Tangential**

Plate 10 ***Burkea africana*** **timber**

RECOMMENDED USES

Wood

Burkea africana timber is heavy and hard therefore suitable for carvings, floorings, turnery and general construction purposes. It is also suitable for furniture and joinery, ship and truck building and timber bridge construction. The wood waste can be used efficiently for fuel. Currently, the species is mainly used locally and traded in limited volume.

Non-wood

The species is nitrogen-fixing, used for bee-hive and also important shade tree. The bark and roots are commonly used for medicinal purposes, against a wide variety of bacteria and fungi. The twigs are used as chewing-stick for dental care.

3.6 *Diospyros zombensis* (Mpweke)

SPECIES IDENTITY

Botanical name: *Diospyros zombensis* (B.L. Burtt) F. White

Synonyms: *Diospyros anitae* F. White
Royena zombensis B.L. Burtt
Royena amnicola B.L. Burtt

Family name: Ebenaceae

Trade name: Mpweke

Local names: **Ngind**: Mpweke

PROPERTIES

Tree description: *Diospyros zombensis* is an evergreen shrub or tree with a height ranging from 2 to 15 m tall and dbh ranging from 80 to 100 cm, with thick canopy and yellow finely reticulate bark. In the study areas, trees had an average height of 15 m and dbh of 22 cm.

Plate 11 Photograph of *Diospyros zombensis* tree

Distribution: *Diospyros zombensis* is native to and distributed in Kenya, Tanzania, Mozambique, Malawi and Zambia in various types of forest, woodland, thicket and wooded grassland at altitudinal range of from 500 to 1,500 m.a.s.l. The species is fairly available in Lindi Cluster.

The wood:

Physical properties

Sapwood: Yellow

Heartwood: Yellow with no distinction from sapwood. darker brown bands, very hard and heavy with coarse texture, irregular and strongly interlocked grain.

Sapwood-Heartwood ratio: No distinction

Basic density: 661 kg/m^3

Air dry density: 798 kg/m^3

Strength properties

- Static bending – centre loading

Modulus of Rupture:	96.3 N/mm^2
Modulus of elasticity:	7,516 N/mm^2
Work to maximum load:	0.39 mmN/mm^3
Total work:	0.44 mmN/mm^3
- Impact bending:	1.18 m
- Compression // to grain:	34.9 N/mm^2
- Hardness:	8,432 N
- Shear:	12.7 N/mm^2
- Cleavage:	R = 19.6 N/mm width
	T = 32.5 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics

Dries very slowly with a strong tendency to distort and with moderate surface checking and splitting. Shrinkage from green to 12% moisture content; radial 2.7% and tangential 4.6%, Movement is classified as medium with radial movement 1.2% and tangential movement 2.3%.

Machining and finishing characteristics

The timber is difficult to work with hand, saw or machine and cause rapid blunting of saws and cutters. The timber must be fed slowly in planing as it tends to ride the cutters, difficult to drill without charring, requires pre-boring for nailing but holds nails well. Steam bending properties are moderate. The timber does not finish well without filling.

Anatomical features
Growth rings: Rings are indistinct and marked by bands of darker tissue with few vessels
Vessels: Arrangement: mostly solitary and in radial groups of 2 to 4, perforations simple.
Density: 2 to 4 per sq. mm (numerous).
Size: 0.1 to 0.4 mm (medium sized, visible to the naked eye).
Gum deposits: Present.
Parenchyma tissue: Moderately abundant, mostly vasicentric and aliform, rarely confluent and terminal.
Rays tissue: Homocellular, storeyed.
Density: 14 per mm.
Size: Fine.

Radial **Tangential**
Plate 12 ***Diospyros zombensis*** **timber**

RECOMMENDED USES

Wood
The durable heartwood and impregnated sapwood are suitable for heavy construction, mining timber, railway sleepers and bridge decking. The heartwood is suitable for furniture and joinery and plywood for interiors.

Non-wood
None yet collected or documented.

3.7 *Erythrophleum africanum* (Mkarati)

SPECIES IDENTITY

Botanical name: *Erythrophleum africanum* (Welw. ex Benth.) Harms

Synonyms: *Caesalpiniodes africanum* (Benth.) Kuntze.
Erythrophleum pubistamineum Henn.
Gleditsia africana Benth.

Family name: Fabaceae sub-family Caesalpiniaceae

Trade name: Mkarati

Local names: **Ngind:** Mpimbalati **Swah:** Mkarati **Kond**: Nchenjele **Eng:** African blackwood

PROPERTIES

Tree description: *Erythrophleum africanum* is a medium to large-sized spreading tree up to a height of 20 m and dbh of 120 cm. In the study areas, trees had an average height of 22 m and dbh of 42 cm. The bark is grey or grey-brown, and rough.

Plate 13 Photograph of *Erythrophleum africanum* tree

Distribution: The species is native to and widespread in tropical Africa from Senegal to Sudan and Tanzania (absent from Uganda and Kenya), southwards to South West Africa, Botswana, Zimbabwe and Mozambique. It occurs in deciduous woodland. *Erythrophleum africanum* can be grown from seed, but wildlings are used as well. Coppicing and pollarding are recommended management practices but coppicing often gives poor results.

The wood:

Physical properties

Sapwood: Yellowish-white.

Heartwood: Dark brown to black with bands of white tissue. Has interlocked grain and uneven medium to coarse texture.

Sapwood-Heartwood ratio: 20:80

Basic density: 1,012 kg/m^3

Air dry density: 1,222 kg/m^3

Strength properties

- Static bending – centre loading

Modulus of Rupture:	136.5 N/mm^2
Modulus of elasticity:	11,132 N/mm^2
Work to maximum load:	0.43 mmN/mm^3
Total work:	0.51 mmN/mm^3

- Impact bending: 1.25 m

- Compression // to grain: 55.7 N/mm^2

- Hardness: 8,105 N

- Shear: 14.8 N/mm^2

- Cleavage: R = 18.1 N/mm width
T = 28.7 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics

The species dries moderately rapidly with slight surface checking and tendency to bow.

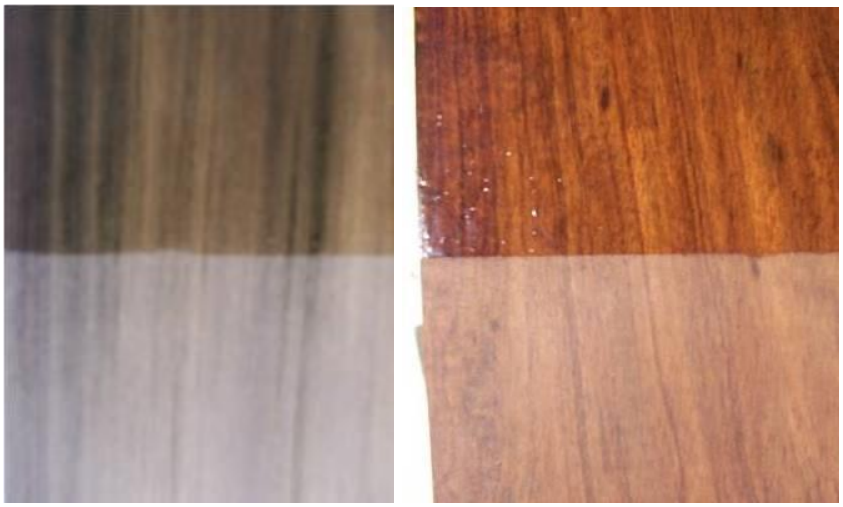
Shrinkage from green to 12% moisture content; tangential 3.1% and radial 4.5%, Movement is classified as small with radial movement 1.3% and tangential movement 2.1%.

Machining characteristics

Difficult to saw and machine and causes rapid blunting of knives and cutters. Intensive steaming must be performed prior to veneer processing.

Finishing characteristics
The species moulds well with good finish**.** The timber is difficult to nail and cannot be screwed without drilling. The wood turns well with good figure and takes a high polish but polishes well.

Anatomical features
Growth rings: rings distinct and are marked by alternating white parenchyma tissue and dark brown wood zones.
Vessels: Arrangement: mostly solitary, a few in radial groups of 2 – 4.
Density: 12 - 30 per 10 sq. mm (numerous)
Size: 0.1 mm to 0.3 mm (moderately large, visible to the naked eye).
Gum deposits: Abundant.
Parenchyma tissue: Distinct to the naked eye, in terminal and broad concentric bands. Paratracheal with vasicentric and aliform superimposed on the bands.
Rays tissue: Arrangement: storied.
Density: 25 to 50 per 5 sq. mm.
Size: Less than 0.05 mm (fine).



Radial **Tangential**

Plate 14 ***Erythrophleum africanum*** **timber**

RECOMMENDED USES

Wood

The timber of *Erythrophleum africanum* is suitable for parquet flooring, joinery and furniture, and veneer, heavy and decorative constructions mine timbers, shipbuilding, boat building, cabinetmaking, musical instruments and kitchen cabinets. The wood can also be used as firewood and to make good-quality charcoal.

Non-wood

Utilized for local medicinal use and gum. The bark is used for relieving toothache stomach-ache and dysmenorrhea, cardiac diseases, leprosy and epilepsy. A hot water extract from pounded roots is drunk to induce vomiting in case of poisoning and as a cure for insanity. However, the bark has also been used as an ordeal poison in Tanzania, Malawi and Zimbabwe.

The gum from the bark is used to make baskets water proof and to fix arrow heads and hoe and axe handles.

3.8 *Lannea schweinfurthii* (Mpome)

SPECIES IDENTITY

Botanical name: *Lannea schweinfurthii* (Engl.) Engl.

Synonyms: *Odina stuhlmanni Engl.*
Lannea kirkii Burtt Davy
Lannea stuhlmannii (Engl.)
Lannea ambigua Engl.
Scassellatia heterophylla Chiov.

Family name: Anacardiaceae

Trade name: Mpome

Local names: **Ngind:** Mpome **Eng:** False marula, bastard marula **Swah:** Ng'ongo mwitu, Ng'ongo pori.

PROPERTIES

Tree description: *Lannea schweinfurthii* is a small to medium-sized tree reaching a height of 7 – 9 m in the domestic gardens but can grow up to 22 m in its natural environment. The dbh range from 60 - 100 cm. In the study areas, trees had an average height of 18 m and dbh of 40 cm. The tree bark is grey or brown, reticulately or longitudinally fissured and flaking-off. The crown, though spreading is light and ovoid in shape having drooping branches.

Distribution: *Lannea schweinfurthii* is native to Eastern Africa - Sudan, Ethiopia, Somalia, Uganda, Kenya, Rwanda, Tanzania, Zambia, Malawi, Mozambique, Botswana, Zimbabwe to S. Africa. The species is widespread in lowland dry forests, river valleys, forests and woodlands of several types including coastal, savannahs and on termite mounds. It also occurs in grasslands at elevations up to 1,820 m.a.s.l. *Lannea schweinfurthii* is propagated by seeds.

Plate 15 Photograph of *Lannea schweinfurthii* tree

The wood:

Physical properties

Sapwood: Creamy to yellowish.
Heartwood: Dark-brown with very fine texture.
Sapwood-Heartwood ratio: 35:65
Basic density: 419 kg/m^3
Air dry density: 506 kg/m^3

Strength properties

- Static bending – centre loading

Modulus of Rupture:	50.7 N/mm^2
Modulus of elasticity:	4,582 N/mm^2
Work to maximum load:	0.26 mm N/mm^3
Total work:	0.36 mm N/mm^3
- Impact bending:	1.06 m
- Compression // to grain:	21.2 N/mm^2
- Hardness:	2,352 N/mm^2
- Shear:	10.2 N/mm^2
- Cleavage:	R = 19.6 N/mm width
	T = 21.4 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics

Dries slowly with little degrade. Shrinkage from green to 12% moisture content; radial 2.5% and tangential 3.9%, movement is classified as small with radial movement 1.7% and tangential movement 2.2%.

Machining and finishing characteristics
The timber saws and planes readily, machining to good finish, glues and polishes well but takes high polish and varnish. The timber is easy to nail but is liable to split. Pre-boring is necessary before screwing.

Anatomical features
Growth rings: Rings are distinct and are marked by a darker zone with fibres predominating at the end of the ring.
Vessels: Arrangement: radial, multiples.
Density: more than 25 per sq. mm (numerous).
Size: less than 0.05 mm (minute, not visible to the naked eye).
Gum deposits: Present.
Parenchyma tissue: Indistinct, sparse, apotracheal.
Rays tissue: Arrangement: storied.
Density: More than 10 per sq. mm (numerous).
Size: less than 0.05 mm (fine).

Radial **Tangential**

Plate 16 ***Lannea schweinfurthii* timber**

RECOMMENDED USES

Wood

The timber is highly suitable for carpentry and joinery, also for construction, utensils and tool handles, and also as fuelwood and charcoal.

Non-wood

Fruits are edible, with sweet flavour eaten as a snack and thirst quencher and can make jellies and alcoholic drinks. The bark is used for making a tea that is used as a blood tonic for treating anaemia. A decoction of the bark is also used for treating diarrhoea, stomach-ache and headache. A red dye obtained from the bark is used for dyeing cloth and the bark is a source of tannins. Moreover, the bark is used to make ropes. The tree is planted for use as live fences.

3.9 *Lonchocarpus bussei* (Mfumbili)

SPECIES IDENTITY

Botanical name: *Lonchocarpus bussei* Harms.

Synonyms: *Lonchocarpus menyharthii* Schinz.
Lonchocarpus fischeri Harms.

Family name: Fabaceae sub-family Papilionaceae

Trade name: Mfumbili

Local names: **Ngind:** Kimbulei Kikulu **Swah:** Mfumbili **Eng:** Narrow lance-pod; apple-leaf **Matum:** Msagawi **Mwer**: Chimbulele

PROPERTIES

Tree description: *Lonchocarpus bussei* is a slender deciduous rather slender tree, ranging from 3 to 15 m in height and growing up to 100 cm in dbh. In the study areas, trees had an average height of 19 m and dbh of 40 cm. The bark is grey to greyish-brown, becoming fissured, rather rough and flaking in older trees with a slash showing pale brown to cream or white colour with red sticky exudate from inside.

Plate 19 Photograph of *Lonchocarpus bussei*

Distribution: *Lonchocarpus bussei* is native to and distributed in Kenya, Tanzania, Malawi, Mozambique, Zambia, Zimbabwe and South Africa at altitudinal range of between 0 to 1,350 m.a.s.l.

The wood:

Physical properties

Sapwood: Greyish-white.

Heartwood: Dark yellowish-brown when dry but is yellowish-brown when freshly sawn, with darker longitudinal streaks.

Sapwood-Heartwood ratio: 30:70

Basic density: 510 kg/m^3

Air dry density: 616 kg/m^3

Strength properties

- Static bending – centre loading

Modulus of Rupture:	53.2 N/mm^2
Modulus of elasticity:	11,132 N/mm^2
Work to maximum load:	0.24 mmN/mm^3
Total work:	0.32 mmN/mm^3
- Impact bending:	1.08 m
- Compression // to grain:	20.3 N/mm^2
- Hardness:	2,568 N
- Shear:	10.1 N/mm^2
- Cleavage:	R = 12.5 N/mm width
	T = 17.5 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics

Dries fairly rapidly, but with a tendency to surface checking. Shrinkage from green to 12% moisture content; tangential 2.2% and radial 2.7%, Movement is classified as small with radial movement 1.6% and tangential movement of 2.3%.

Machining characteristics

Works well by machine but hard to work with hand tools. Easy to saw when dried, planes well but only in the growth increments direction.

Finishing characteristics

The species moulds cleanly to an excellent finish**.** The timber is difficult to sand and glue and is very difficult to nail or screw without pre-boring.

Anatomical features
Growth rings: rings are distinct and are marked by pore clusters at the start of the ring and a darker zone with fibres predominating at the end of the ring.
Vessels: Arrangement: radial multiples and also radial oblique.
Density: more than 25 per sq. mm (numerous).
Size: Less than 0.05mm (minute, not visible to the naked eye).
Gum deposits: Present.
Parenchyma tissues: Distinct, sparse, apotracheal.
Rays tissue: Arrangement: storied.
Density: More than 10 per mm.
Size: Less than 0.05 mm (fine).

Radial **Tangential**
Plate 20 ***Lonchocarpus bussei* timber**

RECOMMENDED USES

Wood
The timber is suitable for making luxury furniture, fancy frames, light flooring, turnery and carvings.

Non-wood
The inner bark is used medicinally as anti-diarrhoea and anti-malaria. The fresh latex is a painkiller for tooth. The bark is used to treat stomach pains but this should be in small dosages.

3.10 *Pseudolachnostylis maprouneifolia* (Msolo)

SPECIES IDENTITY

Botanical name: *Pseudolachnostylis maprouneifolia* Pax.

Synonyms: No synonym recorded for this species

Family name: Euphorbiaceae

Trade name: Msolo

Local names: **Eng:** Duiker-berry, kudu berry; **Swah:** msolo; Matum: muhoro

PROPERTIES

Tree description: *Pseudolachnostylis maprouneifolia* is an attractive, round, single-stemmed deciduous and dioaceous tree, growing up to 12 m high and dbh of 20 cm. in the study areas, trees had an average height of 15 m and dbh of 20 cm. The bark is greyish to dark brown. It is fairly slow growing but in its initial stages of establishment, the plant grows much faster.

Plate 17 Photograph of *Pseudolachnostylis maprouneifolia* tree

Distribution: *Pseudolachnostylis maprouneifolia* is the only species in this genus and naturally occurs only on the African continent, in mixed deciduous vegetation and in woodland, wooded grassland, riverine fringes and on rocky ground from Democratic Republic of Congo, Burundi and Tanzania to Zimbabwe, Namibia, Botswana and northern S. Africa. It grows at an altitudinal range of between 300 – 1,620 m.a.s.l.

Pseudolachnostylis maprouneifolia is not threatened but the ecosystem in which it occurs is threatened due to anthropological factors. This also, is the situation in Lindi and Ruvuma clusters.

The wood:

Physical properties

Sapwood: White, very wide.

Heartwood: Yellowish–brown with fine pale and undulating stripes alternating with darker ones. The grain is irregular with a medium texture.

Sapwood-Heartwood ratio: 45:55

Basic density: 680 kg/m^3

Air dry density: 821 kg/m^3

Strength properties

- Static bending – centre loading

Modulus of Rupture:	82.0 N/mm^2
Modulus of elasticity:	10,220 N/mm^2
Work to maximum load:	0.19 mmN/mm^3
Total work:	0.21 mmN/mm^3
- Impact bending:	1.06 m
- Compression // to grain:	53.8 N/mm^2
- Hardness:	6,882 N
- Shear:	13.7 N/mm^2
- Cleavage:	R=11.4 N/mm width
	T=12.6 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics

Seasons slowly with tendency to surface checking. Shrinkage from green to 12% moisture content; radial 2.5% and tangential 3.2%. Movement is classified as small with radial movement 1.1% and tangential movement 1.3%.

Machining and finishing characteristics
Saws easily and machines to excellent finish. Difficult to nail and liable to splitting

Anatomical features
Growth rings: Absent.
Vessels: Arrangement: diffuse-porous.
Density: 14 to 24 per sq. mm (numerous).
Size: 0.05 mm to 0.1 mm.
Gum deposits: Present.
Parenchyma tissue: Absent or indistinct, diffuse.
Rays tissue: Density: 10 to 16 per mm.
Size: Less than 0.05 mm (fine).

Radial **Tangential**

Plate 18 ***Pseudolachnostylis maprouneifolia* timber**

RECOMMENDED USES

Wood
The wood is light and is satisfactory for construction purposes. It is suitable for building and firewood.

Non-wood
Pseudolachnostylis maprouneifolia is an excellent aesthetic and shade tree. It is also potential as fodder for cattle and its extracts from bark treat diarrhea and pneumonia.

3.11 *Pteleopsis myrtifolia* (Mngoji)

SPECIES IDENTITY

Botanical name: *Pteleopsis myrtifolia* (M.A. Lawson) Engl. & Diels

Synonyms: *Pteleopsis stenocarpa* Engl.
Pteleopsis obovata Hutch.

Family name: Combretaceae

Trade name: Mngoji

Local names: **Eng:** Stink-bushwillow; two-winged stinkbush **Swah:** Mngoji; Mlakwenzi

PROPERTIES

Tree description: *Pteleopsis myrtifolia* is a small to large deciduous tree with height ranging between 3 to 20 m, and dbh ranging from 30 to over 100 cm. In the study areas, trees had an average height of 18 m and dbh of 60 cm. The bark is grey, smooth and adhering with narrow fissures forming small ridges.

Plate 21 Photograph of *Pteleopsis myrtifolia* tree

Distribution: *Pteleopsis myrtifolia* is native to and distributed in Kenya, Tanzania, Malawi, Zambia, Angola, Botswana, Zimbabwe, Mozambique and north-eastern South Africa.

The wood:

Physical properties

Sapwood: Cream coloured and distinct.
Heartwood: Yellowish when freshly sawn and turns to yellowish brown or greenish brown when dry.
Sapwood-Heartwood ratio: 25:75
Basic density: 651 kg/m^3
Air dry density: 786 kg/m^3

Strength properties

- Static bending – centre loading

Modulus of Rupture:	96.3 N/mm^2
Modulus of elasticity:	11,295 N/mm^2
Work to maximum load:	0.25 mmN/mm^3
Total work:	0.38 mmN/mm^3

- Impact bending: 1.18 m
- Compression // to grain: 30.8 N/mm^2
- Hardness: 4,358 N
- Shear: 11.2 N/mm^2
- Cleavage: R = 18.4 N/mm width
T = 23.3 N/mm width
*R = Radial, T = Tangential

Seasoning characteristics

Dries with little degrade Shrinkage from green to 12% moisture content; radial 2.2% and tangential 4.7%, Movement is classified as medium with radial movement 1.3% and tangential movement 1.6%.

Machining characteristics

The timber is moderately difficult to saw and machine and tends to tear in planing and requires a cutting angle of 15^0. The timber also tends to break at the edges in turning and moulding but mortises cleanly.

Finishing characteristics

Finishes well without filling however, the timber is difficult to nail and is liable to split.

Anatomical features
Growth rings: Rings are indistinct and marked by bands of darker tissue with few vessels.
Vessels: Arrangement: mostly solitary and radial pairs and multiples.
Density: 7 to 8 per sq. mm (numerous).
Size: 0.1 to 0.4 mm (medium sized, visible to the naked eye).
Gum deposits: Absent.
Parenchyma tissue: Absent.
Rays tissue: Density: 6 to 8 per mm.
Size: Fine.

Radial **Tangential**

Plate 22 ***Pteleopsis myrtifolia*** **timber**

RECOMMENDED USES

Wood

The timber from *Pteleopsis myrtifolia* is hard, makes good furniture and can be used for construction.

Non-wood

In Tanzania leaf sap, is drunk to treat dysentery threatening abortion. Roots are used as treatment of sterility, venereal diseases, dysentery and excessive menstruation. It is also externally applied to treat sores. Elsewhere, the wood is used as a source of smoke for preserving food. The young stems are used in basketry.

3.12 *Sclerocarya birrea* (Mng'ongo)

SPECIES IDENTITY

Botanical name: *Sclerocarya birrea* (A. Rich.) Hochst.

Synonyms:

Family name: Anacardiaceae

Trade name: Mng'ongo

Local names: **Swah:** Mng'ongo; Mng'ongo pori **Eng:** Marula

PROPERTIES

Tree description: *Sclerocarya birrea* is a medium-sized to large deciduous tree with an erect trunk and rounded crown evergreen tree with height ranging between 12 - 24 m, a clear bole reaching 8 m and dbh of 25 – 30 cm. In the study areas, trees had an average height of 18 m and dbh of 28 cm. The bark is yellow to grey-black, splitting into irregular flakes. The slash from bark is blood-red, turning brown upon hardening.

Plate 23 Photograph of *Sclerocarya birrea* tree

Distribution: *Sclerocarya birrea* is native and widespread in Africa from Ethiopia to South Africa, in various types of woodland, on sandy soil or occasionally sandy loam. It grows easily from seed sown in washed river sand in spring. It can also grow from a truncheon planted in the early spring. It is fast-growing, with a growth rate of up to 1.5 m per year.

The wood:

Physical properties

Sapwood: Light reddish-brown to whitish with no definite heartwood.

Heartwood: Light reddish-brown to whitish with no distinction from sapwood.

Basic density: 545 kg/m^3

Air dry density: 658 kg/m^3

Strength properties

- Static bending – centre loading

Modulus of Rupture:	51.0 N/mm^2
Modulus of elasticity:	5,607 N/mm^2
Work to maximum load:	0.25 mmN/mm^3
Total work:	0.27 mmN/mm^3

- Impact bending: 1.12 m

- Compression // to grain: 29.3 N/mm^2

- Hardness: 2,388 N

- Shear: 11.0 N/mm^2

- Cleavage: R= 28.7 N/mm width

T= 62.3 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics

Seasons slowly with tendency to surface checking. Shrinkage from green to 12 % moisture content; radial 1.2% and tangential 3.2%. Movement is classified as small with radial movement 1.1% and tangential movement 1.1%.

Machining and finishing characteristics

The wood is relatively soft and light, saws easily and machines to excellent finish. Difficult to nail and liable to splitting.

Anatomical features

Growth rings: Absent or indistinct.

Vessels: Arrangement: wood diffuse-porous, simple perforation plates.

Density: 5 to 20 per sq. mm.

Size: 0.07 mm to 0.1 mm.

Gum deposits: Present.

Parenchyma tissue: Absent or indistinct, diffuse.

Rays tissue: Density: 4 to 12 per mm.

Size: Less than 0.05 mm (fine).

Radial **Tangential**

Plate 24 ***Sclerocarya birrea* timber**

RECOMMENDED USES

Wood

The timber of *Sclerocarya birrea* is suitable for cabinet making, paneling, crating, turnery and furniture. It is equally potential for carvings and household utensils like spoons, mortars, pestles, bowls and various local crafts and saddles.

Non-wood

The fruit is edible, eaten either fresh or made into a delicious jelly. It is also famous for preparation of local beers and the famous amarula drink, a liqueur which is available commercially. A decoction of the bark treats dysentery and diarrhoea as laxatives, rheumatism, haemorrhoids and has a prophylactic effect against malaria. A drink made from marula leaves is used for the treatment of gonorrhoea.

3.13 *Toona ciliata* (Msederela)

SPECIES IDENTITY

Botanical name: *Toona ciliata* M.Roem.

Family name: Meliaceae

Trade name: Msederela

Local names: **Swah:** Msederela **Eng:** Red cedar; Toon; Toona; Australian red cedar; Burma cedar; Indian cedar

PROPERTIES

Tree description: *Toona ciliata* is a deciduous tree that is native to Australia, growing up to around 60 m in height and 300 cm in dbh with large branches that create a spreading crown. In the study areas, trees had an average height of 30 m and dbh of 60 cm. The bark is yellow to grey-black, splitting into irregular flakes. The slash from bark is blood-red, turning brown upon hardening.

Plate 23 Photograph of *Toona ciliata* tree

Distribution: *Toona ciliata* is native to tropical Asia and tropical Australia, but is now much cultivated throughout the tropics for its timber and as an ornamental or wayside tree. It is extensively planted in tropical Africa, particularly in East and southern Africa, but also locally in West Africa, Madagascar and Mauritius. It has locally become naturalized in southern Africa.

The wood:

Physical properties

Sapwood: Greyish white to pink.

Heartwood: Pale red to reddish brown, darkening to dark red-brown on exposure.

The grain is usually straight, sometimes interlocked, texture rather coarse and uneven.

Sapwood-Heartwood ratio: 20:80

Basic density: 461 kg/m^3

Air dry density: 557 kg/m^3

Strength properties

- Static bending – centre loading

Modulus of Rupture:	71.5 N/mm^2
Modulus of elasticity:	9,220 N/mm^2
Work to maximum load:	0.22 mmN/mm^3
Total work:	0.27 mmN/mm^3

- Impact bending: 1.02 m

- Compression // to grain: 36.3 N/mm^2

- Hardness: **3**,173 N

- Shear: 11.2 N/mm^2

- Cleavage: R = 18.4 N/mm width

T = 27.8 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics

Seasons slowly with tendency to surface checking, warping and cupping. Close spacing of stickers and weighting of stacks is recommended. Once dry, the wood is moderately stable in service. Shrinkage from green to 12 % moisture content; radial 3.8% and tangential 6.3%. Movement is classified as moderate with radial movement of 1.0% and tangential movement of 1.7%.

Machining and finishing characteristics

The wood is easy to saw, cross-cut and plane to smooth surface and takes a good polish. Some material tends to produce a woolly finish and the use of sharp tools is therefore recommended. Mortising, turning and sanding give moderate results, boring sometimes gives poor results. Nailing is easy, but the nail-holding capacity is moderate. The gluing properties are rated as good. The wood peels well and the veneer is of good quality and has a nice figure. The veneer can be glued to produce good-quality plywood.

Anatomical features
Growth rings: Absent.
Vessels: Arrangement: exclusively solitary.
Density: 30 to 65 per 10 sq. mm.
Size: 0.05 mm to 0.1 mm.
Gum deposits: Present.
Parenchyma tissue: Absent or **i**ndistinct, diffuse.
Rays tissue: Density: 50 to 80 per 5 mm.
Size: Less than 0.05 mm (fine).

Radial **Tangential**
Plate 24 ***Toona ciliata* timber**

RECOMMENDED USES

Wood
The timber of *Toona ciliata* is very highly valued in Australia, its place of origin and is considered suitable for cabinet making, turnery and furniture. It is also extensively used for wood panelling and construction, including shipbuilding.

Non-wood
The flowers yield a dye to colour silk. The bark may be used for tanning leather, and has been traditionally used to make twine and string bags. A number of medicinal uses of the species has been recorded to treat dysentery venereal diseases, and wounds. *Toona ciliata* is commonly planted as an ornamental tree, shade tree in banana plantations and for erosion control, firebreak and for reforestation. The foliage can serve as

fodder, and has been used in tropical Asia as a vegetable. An aromatic oil can be extracted from the wood and fruits. Flowering trees are reported as a good source of nectar for honey bees.

3.14 *Vitex doniana* (Mfuru)

SPECIES IDENTITY

Botanical name: *Vitex doniana* Sweet

Synonyms:
Vitex cienkowskii Kotschy & Peyr.
Vitex cuneata Schumach. & Thonn.
Vitex dewevrei De Wild. & T.Durand
Vitex homblei De Wild.
Vitex hornei Hemsl.
Vitex pachyphylla Baker
Vitex paludosa Vatke
Vitex puberula Baker
Vitex umbrosa G.Don ex Sabine

Family name: Lamiaceae

Trade name: Mfuru

Local names: **Swah:** Mfudu; Mfuru; Mfuu **Eng:** Black plum

PROPERTIES

Tree description: *Vitex doniana* is a medium to large deciduous tree with height ranging between 20 to 25 m, a clear bole reaching 11 m and dbh ranging from 90 to 160 cm. In the study areas, trees had an average height of 18 m and dbh of 80 cm. The tree is often slightly fluted at base and has a heavy and rounded crown. The bark surface is greyish white to pale greyish brown, fissured and scaly, inner bark yellowish white, darkening to brown.

Plate 23 Photograph of *Vitex doniana* tree

Distribution: *Vitex doniana* is native to Tropical Africa, extending from Senegal to Sudan, south to Angola, Zambia and Mozambique. It inhabits dense forest, wooded savannah, coastal savannah and riverine thickets as well as extending as high as upland grassland. The altitudinal range is from near sea level to 1,850 m.a.s.l. The tree is also cultivated or semi-cultivated near villages for its multipurpose uses.

The wood:

Physical properties

Sapwood: White, very wide.

Heartwood: Yellowish brown or greyish brown, resembles *Tectona grandis* (teak). The grain is straight to wavy or interlocked and texture moderately fine to moderately coarse.

Sapwood-Heartwood ratio: 45:55

Basic density: 596 kg/m^3

Air dry density: 720 kg/m^3

Strength properties

- Static bending – centre loading

Modulus of Rupture:	127.0 N/mm^2
Modulus of elasticity:	6,210 N/mm^2
Work to maximum load:	0.14 mmN/mm^3
Total work:	0.192 mmN/mm^3

- Impact bending: 1.06 m

- Compression // to grain: 41.9 N/mm^2

- Hardness: **3**,169 N

- Shear: 7.7 N/mm^2

- Cleavage: R=54.2 N/mm width
T=72.7 N/mm width

*R = Radial, T = Tangential

Seasoning characteristics

Seasons fairly easily with little tendency to surface checking and cupping. Shrinkage from green to 12% moisture content; radial 1.1% and tangential 3.3%, Movement is classified as small with radial movement 1.1% and tangential movement 1.1% and once dry, the wood is stable in service.

Machining and finishing characteristics

Saws and machines easily, however difficult to plane to excellent finish (produces silky or furry surface) due to the presence of interlocked grain. It nails well with

little splitting nevertheless, with little nail holding capacity.

Anatomical features
Growth rings: Indistinct.
Vessels: Arrangement: diffuse-porous, exclusively solitary, scalariform.
Density: 50 to 200 per 10 sq. mm.
Size: 0.1 mm to 0.2 mm.
Gum deposits: Present.
Parenchyma tissue: Axial parenchyma scanty paratracheal to vasicentric.
Density: 3 to 8 per strand.
Rays tissue: Density: 40 to 120 per 10 mm.
Size: Less than 0.05 mm (fine).

Radial **Tangential**

Plate 24 ***Vitex doniana* timber**

RECOMMENDED USES

Wood

The timber of *Vitex doniana* is suitable for a variety of uses from cabinet making, turnery and furniture, vats, carving, tool handles and gunstocks. It is also suitable for light construction, light flooring, joinery, interior trim, shipbuilding, vehicle bodies and re-constituted boards.

Non-wood

Vitex doniana is planted as an ornamental shade tree, also contributing to the improvement of soil fertility by litter production and nitrogen-fixing ability of its roots. The species also, provides edible fruits that are rich in vitamin A and B and minerals and often used to make jam, beverage and alcoholic liquor and wine. Young leaves are eaten as a vegetable or in sauces. *Vitex doniana* has numerous applications in traditional medicine. The twigs are used as chewing sticks and the blackish extract obtained from leaves, bark, roots and fruits is used as ink and as a dye for clothes. Moreover, the flowers serve as source of nectar for honeybees and cattle browse the foliage of the tree.

Table 3 Summary of average physical and mechanical properties of the 14 lesser-known timber species in FORVAC operational area in Tanzania

Scientific Name, Trade Name	Density, Kg/m³		Strength properties											Shrinkage at 12%		Movement	
	Basic	Air dry	MOR, N/mm²	MOE, N/mm²	Work to maximum load	Total work, mmN/mm³	Impact Bending, m	Compress-ion, N/mm³	Shear, N/mm³	Hardness, N	Cleavage N/mm width		Remarks on strength	Radial, %	Tange-ntial, %	Radial, %	Tange-ntial, %
											Radial	Tange-ntial					
Brachystegia allennii, (Muhumbuti)	587	709	102.7	10,572	0.27	0.33	1.05	41.3	12.1	3,565	16.6	28.7	Excellent for its medium density, wears slowly and evenly	1.5	2.0	1.2	1.3
	Medium		Strong	Stiff	Strong	Strong	Strong	Strong	Medium	Medium	Strong	Strong		Small			
Brachystegia floribunda (Mtondolo)	506	611	96.0	8,188	0.27	0.31	1.05	33.5	9.9	3,488	13.4	25.3	Goodt for its low density, however splits easily	2.1	4.3	1.3	2.8
	Light		Strong	Medium	Strong	Strong	Strong	Medium	Weak	Medium	Strong	Strong		Medium			
Brachystegia glaberrima (Mtondolo)	522	630	109.4	8,885	0.28	0.35	1.03	35.0	10.8	3,658	15.8	32.2	Excellent for its low density	2.0	2.9	1.1	1.1
	Light		Strong	Medium	Strong	Strong	Strong	Medium	Medium	Medium	Strong	Strong		Small			
Brachystegia utilis (Mtundu)	560	676	79.8	11,242	0.31	0.36	1.06	36.6	11.9	4,236	15.6	20.1	Excellent for its medium density, wears slowly and evenly	3.1	4.2	1.7	2.5
	Medium		Strong	Stiff	Strong	Strong	Strong	Medium	Medium	Strong	Strong	Strong		Small			
Burkea africana (Mkarati)	956	1,155	112.3	14,196	0.41	0.56	1.21	62.6	21.5	7,610	17.5	93.3	Excellent, wears slowly and evenly	3.6	5.2	1.0	1.1
	Heavy		Strong	Stiff	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong		Small			
Diospyros zombensis (Mpweke)	661	798	96.3	7,516	0.39	0.44	1.18	34.9	12.7	8,432	19.6	32.5	Excellent for its medium density, wears slowly and evenly	2.7	4.6	1.2	2.3
	Medium		Strong	Medium	Strong	Strong	Strong	Medium	Medium	Strong	Strong	Strong		Medium			
Erythrophleum africanum (Mkarati)	1,012	1,222	136.5	11,132	0.43	0.51	1.25	55.7	14.8	8,105	18.1	28.7	Excellent timber, wears slowly and evenly	3.1	4.5	1.3	2.1
	Heavy		Strong	Stiff	Strong	Strong	Strong	Strong	Medium	Strong	Strong	Strong		Small			
Lannea schweinfurthii (Mpome)	419	506	50.7	4,582	0.26	0.36	1.06	21.2	10.2	2,352	19.6	21.4	Good for its low density	2.5	3.9	1.7	2.2
	Light		Medium	Elastic	Strong	Strong	Strong	Medium	Medium	Medium	Strong	Strong		Small			
Lonchocarpus bussei (Mfumbili)	510	616	53.2	11,132	0.24	0.32	1.08	20.3	10.1	2,568	12.5	17.5	Excellent for its low density	2.2	2.7	1.6	2.3
	Light		Medium	Stiff	Strong	Strong	Strong	Medium	Medium	Medium	Strong	Strong		Small			
Pseudolachnostylis maprouneifolia (Msolo)	680	821	82	10,220	0.19	0.21	1.06	53.8	13.7	6,882	11.4	12.6	Excellent for its medium density, wears slowly and evenly	2.5	3.2	1.1	1.3
	Medium		Strong	Stiff	Strong	Strong	Strong	Strong	Medium	Strong	Strong	Strong		Small			
Pteleopsis myrtifolia (Mngoji)	651	786	96.3	11,295	0.25	0.38	1.18	30.8	11.2	4,358	18.4	23.3	Excellent for its medium density, wears slowly and evenly	2.2	4.7	1.3	1.6
	Medium		Strong	Stiff	Strong	Strong	Strong	Medium	Medium	Strong	Strong	Strong		Small			
Sclerocarya birrea (Mngóngo)	545	658	51.0	5,607	0.25	0.27	1.12	29.3	11.0	2,388	28.7	62.3	Excellent for its medium density, wears slowly and evenly	1.2	3.2	1.1	1.1
	Medium		Medium	Medium	Strong	Strong	Strong	Medium	Medium	Medium	Strong	Strong		Small			
Toona ciliata (Msederela)	461	557	71.5	9,220	0.22	0.27	1.02	36.3	11.2	3,173	18.4	27.8	Excellent for its low density	3.8	6.3	1.0	1.7
	Light		Strong	Medium	Strong	Strong	Strong	Medium	Medium	Medium	Strong	Strong		Small			
Vitex doniana (Mfuru)	596	720	127.0	6,210	0.14	0.19	1.06	41.9	7.7	3,169	54.2	72.7	Good for its medium density, however splits easily	1.1	3.3	1.1	1.1
	Medium		Strong	Medium	Strong	Strong	Strong	Strong	Weak	Medium	Strong	Strong		Small			

Table 4: Summary of some average physical properties of the 14 lesser-known timber species in FORVAC operational area in Tanzania

S N	Scientific Name, Trade Name	Dbh (cm)	Height (m)	Sap:Heart Wood Ratio	Remarks
1.	*Brachystegia allennii* Hutch. & Burtt Davy, (Muhumbuti)	37	19	42:58	- A medium sized tree capable of producing one saw log - Present reasonable content of heartwood
2.	*Brachystegia floribunda* Benth. (Mtondolo)	55	28	41:59	- A medium sized tree capable of producing two saw logs - Present reasonable content of heartwood
3.	*Brachystegia glaberrima* R.E.Fr. (Mtondolo)	45	23	32:68	- A medium sized tree capable of producing two saw logs - Present high content of heartwood
4.	*Brachystegia utilis* Hutch. & Burtt Davy (Mtundu)	47	20	23:77	- A medium sized tree capable of producing one saw log - Present exceptionally high content of heartwood
5.	*Burkea africana* Hook. (Mkarati)	41	23	16:84	- A medium sized tree capable of producing one saw log - Present exceptionally high content of heartwood
6.	*Diospyros zombensis* (B.L. Burtt) F. White (Mpweke)	22	15	NA	- A medium sized tree capable of producing one saw log - Present no distinction between sapwood and heartwood
7.	*Erythrophleum africanum* (Welw. ex Benth.) Harms (Mkarati)	42	22	20:80	- A medium sized tree capable of producing two saw logs - Present exceptionally high content of heartwood
8.	*Lannea schweinfurthii* (Engl.) Engl. (Mpome)	40	18	35:65	- A medium sized tree capable of producing one saw log - Present high content of heartwood
9.	*Lonchocarpus bussei* Harms (Mfumbili)	40	19	30:70	- A medium sized tree capable of producing one saw log - Present high content of heartwood
10.	*Pseudolachnostylis maprouneifolia* Pax. (Msolo)	20	15	45:55	- A medium sized tree capable of producing one saw log - Present reasonable content of heartwood
11.	*Pteleopsis myrtifolia* (M.A.Lawson) Engl. & Diels (Mngoji)	60	18	25:75	- A medium sized tree capable of producing one saw log - Present reasonable content of heartwood
12.	*Sclerocarya birrea* (A. Rich.) Hochst. (Mng'ongo)	28	18	NA	- A medium sized tree capable of producing one saw log - Present no distinction between sapwood and heartwood
13.	*Toona ciliata* M. Roem. (Msederela)	60	30	20:80	- A medium sized tree capable of producing three saw logs - Present exceptionally high content of heartwood
14.	*Vitex doniana* Sweet. (Mfuru)	80	18	45:55	- A medium sized tree capable of producing one saw log - Present reasonable content of heartwood

4. INFERENCE FROM THE RESULTS

4.1 General

The summarized results for this study, as portrayed in Table 3 and Table 4 and classified in Appendix II clearly indicate that the 14 studied lesser-known timber species in the FORVAC operational area in Tanzania have most of their timber properties comparable and some or even superior to those of the better-known and over-exploited commercial timber species of Tanzania as accounted by Bryce (1967). These timbers can therefore be used as substitutes of the already unavailable stock.

Nevertheless, species that are also used for other important purposes as food including *Sclerocarya birrea* and *Vitex doniana* should only be harvested for timber when they reach moribund stage. On the other hand, this calls for proper and thorough management plans for timber market sustainability.

4.2 Physical properties

4.2.1 Appearance and colour

Substitution of the timber based on appearance and colour or for decorative purposes can be reached at using the timber's heartwood (Table 5) as advocated by Bryce (1967) and Bunster (1995).

As portrayed in Table 5, *Pteleopsis myrtifolia* and *Burkea africana* are greenish brown, the colour which resembles timber from *Milicia excelsa* (Mvule), *Xylopia parviflora, Beilschmiedia kweo* (Mfimbo) and *Afrormosia angolensis* (Mbanga or East African afrormosia). Most of the other species including *Brachystegia* spp. have dark bown heartwoods, being potential substitutes of *Pterocarpus angolensis* (Mninga), *Brachystegia boehmii* (Myombo), *Combretum imberbe* (Mlama) and *Combretum schumannii* (Mpera mwitu).

Erythrophleum africanum is dark brown to black therefore producing a dark, fine-grained timber suitable for turnery and carving. This species can with confidence be recorded as a substitute for *Dalbergia melanoxylon* (African blackwood) and *Acacia nigrescens* (Knobthorn).

Whereas *Lonchocarpus bussei* has heartwood which is similar in colour with the timber from *Bobgunia madagascariensis* (Paurosa/Msekeseke), *Toona ciliata* is similar to *Khaya anthotheca* (East African Mahogany/Mkangazi) and *Cedrella odorata* (Spanish cedar/Msederela).

Table 5: Substitution of timber species based on appearance and colour of heartwood

SN	Studied species	Colour and appearance of heartwood	Substitute species
1.	*Brachystegia allennii* (Muhumbuti)	Dark brown or red-brown, with fine white streaks	*Pterocarpus angolensis* (Mninga), *Brachystegia boehmii* (Myombo), *Combretum imberbe* (Mlama) and *Combretum schumannii* (Mpera mwitu)
2.	*Brachystegia floribunda* (Mtondolo)	Reddish-brown with yellow to dark brown bands	
3.	*Brachystegia glaberrima* (Mtondolo)	Reddish to dark-brown	
4.	*Brachystegia utilis* (Mtundu)	Reddish-brown, yellowish-brown to dark brown	
5.	*Burkea africana* (Mkarati)	Dark brown with grey and green tinges	*Milicia excelsa* (Mvule), *Xylopia parviflora* (Bitterwood), *Beilschmiedia kweo* (Mfimbo) and *Afrormosia angolensis* (Mbanga)
6.	*Diospyros zombensis* (Mpweke)	Yellow	
7.	*Erythrophleum africanum* (Mkarati)	Dark brown to black with bands of white tissue	*Dalbergia melanoxylon* (Mpingo) and *Acacia nigrescens* (Knobthorn)
8.	*Lannea schweinfurthii* (Mpome)	Dark-brown with very fine texture	*Pterocarpus angolensis* (Mninga) and *Brachystegia boehmii* (Myombo)
9.	*Lonchocarpus bussei* (Mfumbili)	Dark yellowish-brown with darker longitudinal streaks	*Bobgunia madagascariensis* (Paurosa/Msekeseke)
10.	*Pseudolachnostylis maprouneifolia* (Msolo)	Yellowish–brown with fine pale undulating stripes	*Milicia excelsa* (Mvule), *Xylopia parviflora* (Bitterwood), *Beilschmiedia kweo* (Mfimbo) and *Afrormosia angolensis* (Mbanga)
11.	*Pteleopsis myrtifolia* (Mngoji)	Yellowish to greenish brown	
12.	*Sclerocarya birrea* Mngóngo)	Light reddish-brown	*Pterocarpus angolensis* (Mninga) and *Brachystegia boehmii* (Myombo)
13.	*Toona ciliata* (Msederela)	Pale red to reddish brown	*Khaya anthotheca* (East African Mahogany/ Mkangazi) and *Cedrella odorata* (Msedrela)
14.	*Vitex doniana* (Mfuru)	Yellowish to greyish brown	*Tectona grandis* (Teak)

4.2.2 Sapwood-Heartwood ratio

The distinction between sapwood and heartwood has important implications for woodworking beyond the obvious implications of color. Whereas heartwood promotes durability and marketability of wood species, sapwood advocates the activities of wood destroying agents during storage and in service. Moreover, sapwood is not as strong, rich or beautiful as heartwood, therefore not preferred in woodworking.

Because sapwood contains the sap-conducting cells of the tree, it tends to have a relatively high moisture content tending to shrink and move considerably when dried. Sapwood can however, being thoroughly coated in polyurethane or paint be used for a small part of the furniture or combined with heartwood to produce two-tone pattern colour.

As also noted by Ogunswusi (2013) in Lesser-Known Timber Species studies in Nigeria, the ratio of heartwood and sapwood varies considerably in different timber species, determining the durability and commercial value of various species.

In the current studies as depicted in Table 4, species with exceptionally high content of heartwood were *Burkea africana* (84%), *Erythrophleum africanum* and *Toona ciliata* (80% each), *Brachystegia utilis* (77%) and *Pteleopsis myrtifolia* (75%). The deployment of *Pseudolachnostylis maprouneifolia* and *Vitex doniana* (55% each), *Brachystegia floribunda* (59%) and *B. allennii* (58%) to service will require extensive preservative treatment using the full cell process, most especially, in uses where they will be in contact with the ground.

4.2.3 Density

The timbers of the species studied range from light, medium to heavy. From Table 3, whereas the light timbers are *Brachystegia floribunda, B. glaberrima, Lannea schweinfurthii, Lonchocarpus bussei* and *Toona ciliata,* the medium density timbers are *Brachystegia allennii, B. utilis, Diospyros zombensis, Pteleopsis myrtifolia, Sclerocarya birrea, Vitex doniana* and *Pseudolachnostylis maprouneifolia.* The heavy timbers are *Burkea africana* and *Erythrophleum africanum.*

The highest density of the most famous commercial timbers of Tanzania reported by Bryce (1967) is 1,282 kg/m^3 for *Dalbergia melanoxylon* (African blackwood). It is clear therefore, that the lesser-known *Erythrophleum africanum* with 1,222 kg/m^3 is a potential substitute of *Dalbergia melanoxylon*.

Likewise, *Diospyros zombensis, Pseudolachnostylis maprouneifolia* and *Pteleopsis myrtifolia* are akin to *Afzelia quanzensis* (833 kg/m^3).

4.2.4 Seasoning characteristics

Most of the species (*Brachystegia allennii, B. glaberrima, B. utilis, Burkea africana, Erythrophleum africanum, Lannea schweinfurthii, Lonchocarpus bussei, Pseudolachnostylis maprouneifolia, Pteleopsis myrtifolia, Sclerocarya birrea, Toona ciliata and Vitex doniana*) have small shrinkage and movement which is an indication that the timber species are stable when in outdoor service despite of the anticipated changes in the weather conditions. This behavior suits for application of the timbers for kitchenware like chopping board, knifes and pallet or spatula knifes which require dishwashing. When seeking for timber with small shrinkage and movement, these species therefore, can substitute *Dalbergia melanoxylon* (African blackwood), *Pterocarpus angolensis* (Mninga) and *Milicia excelsa* (Mvule) the three most famous commercial timbers of Tanzania.

Brachystegia floribunda and *Diospyros zombensis* have medium shrinkage and swelling therefore only suitable for indoor uses. Seasoning of such timbers need to be carefully conducted, in order to avoid timber degrade.

4.2.5 Workability

Most of the studies species work well by machines, except *Brachystegia floribunda, Brachystegia utilis, Diospyros zombensis, Erythrophleum africanum* and *Pteleopsis myrtifolia* which are difficult to saw and cause blunting of cutting tools. *Burkea Africana, Brachystegia glaberrima* and *Lonchocarpus bussei* work well by machine however they are hard to work with hand tools. On the other hand, *Vitex doniana* saws and machines easily, however it is difficult to plane to excellent finish as it produces silky or furry surface due to the presence of interlocked grain.

Whereas *Lonchocarpus bussei* and *Sclerocarya birrea* are difficult to nail and screw needing pre-boring as a pre-requisite, *Lannea schweinfurthii* takes high polish and varnish during finishing.

Comparably, while the African blackwood is difficult to saw and plane as it causes rapid blunting of the cutters, Mvule and Mninga work easily. However, Mvule requires a cutting angle of 150 in planing. The three timbers mould and sand to excellent finish.

4.3 Strength properties

The timbers of all studied lesser-known species are strong in static bending (work to maximum load and total work), impact bending and cleavage. They are also either strong or medium in compression, hardness and shear, except *Brachystegia floribunda* which is weak in shear.

Likewise, the three famous commercial timbers of Tanzania are strong in static bending, compression, hardness and cleavage and moderate in the rest. For structural designs therefore, all of the 14 Lesser-Known Timber Species can substitute African blackwood, Mninga and Mvule.

5 CONCLUSION AND RECOMMENDATIONS

The properties of the studied lesser-known timber species indicate that these species can be used as substitutes of the famous commercial timbers of Tanzania which are already relatively unavailable.

Since the technical information gathered from the 14 Lesser-Known and Lesser-Utilized Timber Species is now available through this catalogue and the developed website (www.miombotimbertanzania.or.tz), it is important that it is brought to the attention of different users.

This calls for the need of increasing market promotion of the timber species, which can be achieved through:

- Annually held exhibitions, the most important of which in Tanzania include the Farmers' Week Exhibitions famously known as Nane Nane and Dar es Salaam International Trade Fair;

- Workshops and seminars with different timber stakeholders;

- Brochures and leaflets containing timber utilization technical data of the studied species; and

- Propagation and domestication of the studied timber species.

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APPENDICES

APPENDIX I GLOSSARY ON IMPORTANT PROPERTIES OF WOOD

PHYSICAL

Density of wood: *Mass of wood per unit of volume*.
It is commonly taken at 12% moisture content (air-dry condition) as the decimal ratio of the oven-dry weight to the volume at a moisture content of 12%.

Figure: *Design or distinctive marking on the surface of wood caused by rays, growth increments, grain, vessel traces or other features*.

Grain: *Arrangement and direction of alignment of wood tissues in relation to the main axis of the stem.*

a) **Interlocked grain**: *Grain produced by alternating the angular fibre orientation in successive layers of growth increments.*
b) **Straight grain**: *Grain obtained when the direction of the fibre alignment is straight and parallel to the main axis of the stem*.
c) Wavy grain: *Grain due to undulations in the direction of fibre alignment*.

Heartwood: *Dead inner core of woody stem encircled by sapwood, generally darker and more durable*.

Movement: *Dimensional changes of wood that arise in timber at equilibrium moisture content due to seasonal or daily changes in the relative humidity of the surrounding atmosphere*.

Sapwood: *Outer portion of a woody stem, usually lighter than core and constituted by active cells*.

Shrinkage: *Reduction in dimension of wood that occurs when timber at fibre saturation point (green timber) is dried to very low moisture content*.
There is little change in the longitudinal dimension. There is virtually no shrinkage parallel to the length of a piece of timber.

a) **Radial shrinkage**: *Shrinkage that occurs perpendicular to the growth rings.* It is shrinkage in the direction towards the centre of the tree.
b) **Tangential shrinkage**: *Shrinkage that occurs in the direction parallel to the growth rings.* It is always a little larger than the shrinkage in the radial direction because radial shrinkage is partly restrained by rays (fibres that run perpendicular to the growth rings).

Texture: *The distinctive physical composition or structure of wood, especially with respect to the size, shape, and arrangement of its woody elements.* It is described as coarse (large elements), fine (small elements) or even (uniform size of elements).

STRENGTH

Strength: *The ability of a material to resist applied stress.*
Resistance may be measured as the maximum stress that a material can endure before failure occurs or to measure the deformation or strain that result from a given level of stress before the point of total failure. The strength of timber refers to the ability of the timber to resist external forces that tend to change the size and shape of the timber. Strength is defined by ultimate stress values which are measured in the laboratory by means of test and defect free specimens. The average values obtained are useful for comparison of one timber with another.

Maximum bending strength (equivalent fibre strength at maximum load, or Modulus of Rupture - MOR): *A measure of the maximum stress which the timber can momentarily sustain when loaded slowly and continuously as a beam.*
This is derived from calculations based on the maximum load recorded on the graph developed when testing the wood, using Monsanto Tensometer.

Modulus of Elasticity - MOE (Stiffness or stress at proportional limit): *A measure of the rigidity of the timber expressed by the ratio of bending stress and the distortion per unit length.*

It is obtained from the deflection and load at the limit proportionality, the limit being the point at which the load – deflection diagram line ceases to be a straight line. This diagram is developed when testing the wood, using Monsanto Tensometer.

Work to maximum load: *A measure of toughness or energy absorbed under bending stress at maximum load.*

It is an indication of the ability of wood to absorb shocks that cause stress beyond the limit of proportionality. Wmax is obtained from the area on the graph enclosed by the deflection line; a line drawn from the point of maximum load, parallel to the characteristic line, to the abscissa. This area is directly measured by a planimeter.

Total work (Toughness): *This is a measure of toughness or energy absorbed under bending stresses that cause total fracture.*

This is derived in the same way as work to maximum load, but the whole area enclosed by the deflection line is measured. Toughness may also be defined as the amount of work required to break a specimen under an impact (load under falling pendulum).

Impact bending strength: *A measure of the resistance of a material to suddenly applied loads*.

This is measured as the height from which a 22 kilogramme hammer must be dropped in order to break a specimen at the centre or by the use of impact pendulum equipment.

Compressive strength parallel to grain: *A measure of the strength of short columns and struts.*

This is obtained from the calculations based on the maximum load recorded to break the test sample.

Hardness: *A measure of the resistance to indentation.*

It is measured by forcing a steel ball into the radial and tangential faces of the test specimen to a depth equal to the radius of the ball.
Shear strength: *A measure of ability to resist internal splitting of one part upon another along the grain.*

It is obtained basing on the calculations using the maximum shear force recorded in breaking the test specimen. This property is required for the design of beams and certain joints.

Cleavage strength: *A measure of the resistance to splitting on the notched specimen.*

This property gives the indication of the nailing and screwing properties of the tested timber. It is obtained basing on the calculations using the maximum cleavage force recorded in breaking the test specimen.

ANATOMICAL FEATURES

Apotracheal parenchyma: *Longitudinal parenchyma arranged independent of the pores.*

a) **Diffuse apotracheal:** *Single parenchyma cells distributed irregularly among fibres.*
b) **Diffuse-in-aggregates:** *Apotracheal parenchyma cells that tend to be grouped in short tangential lines, sometimes extending from ray to ray.*

Banded parenchyma: *Parenchyma tissues forming concentric lines or bands these are differentiated into two types.*

a) **Apotracheal banded:** *Mainly independent of pores.*
b) **Paratracheal banded:** *Mainly associated with the pores.*

Boundary parenchyma: *Longitudinal parenchyma occurring either as occasional cells or forming a more or less continuous layer of one or more cells in width at the margin of a growth ring.*

a) **Terminal:** *If the longitudinal parenchyma cells occur at the end of the growth ring.*
b) **Initial:** *If the longitudinal parenchyma cells occur at the beginning of the growth ring.*

Paratracheal parenchyma: *Longitudinal parenchyma associated with the vessels of vascular tracheids.*

a) **Scanty paratracheal:** *Paratracheal parenchyma confined to a few cells around the vessel.*
b) **Vasicentric paratracheal:** *Paratracheal parenchyma formed in a more or less complete sheath, one or more cell wide around a vessel.*
c) **Aliform paratracheal:** *Paratracheal parenchyma that extends from the flanks of the pore, forming wing-like lateral extensions.*
d) **Confluent paratracheal:** *Aliform parenchyma forming irregular tangential or diagonal bands that coalesce.*

APPENDIX II KEY FOR IMPORTANT PROPERTIES OF WOOD

Air dry density (kg/m^3)

Light	< 644
Medium	645 – 950
Heavy	>950

Shrinkage and movement (%)

	Radial	Tangential
Small	<2.0	<3.0
Medium	2.0 – 2.5	4.0
Large	>2.5	>4.0

Static bending: Modulus of Rupture (N/mm^2)

<30	Low strength
30 – 60	Medium strength
>60	High strength

Static bending: Modulus of Elasticity (N/mm^2)

<5,000	Low stiffness
5,000 – 10,000	Medium stiffness
>10,000	High stiffness

Static bending: Work to Maximum Load (mmN/mm^3)

<0.05	Low strength
0.05 – 0.10	Medium strength
>0.1	High strength

Static bending: Total Work (mmN/mm^3)

<0.05	Low strength
0.05 – 0.10	Medium strength
>0.1	High strength

Impact bending (m)

<0.5	Low strength
0.5 – 1.0	Medium strength
>1.0	High strength

Compression parallel to grain (N/mm^2)

<20	Low strength
20 – 40	Medium strength
>40	High strength

Hardness (N/mm^2)

<2,000	Low strength
2,000 – 4,000	Medium strength
>4,000	High strength

Shear (N/mm^2)

<10	Low strength
10 – 20	Medium strength
>20	High strength

Cleavage (N/mm)

<5	Low strength
5 – 10	Medium strength
>10	High strength

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