PROPERTIES OF *NESOGORDONIA HOLTZII* SUBSP *HOLTZII* (MOSS) CAPURON: A LESSER KNOWN TIMBER SPECIES FROM KILINDI DISTRICT, TANZANIA

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ABSTRACT

Nesogordonia holtzii subsp *holtzii* (Moss) Capuron is a lesser-known timber species belonging to the family Sterculiaceae. The species is distributed in the eastern tropical Africa in association with other tree species as *Newtonia buchananii, Albizia versicolor, Allanblackia stuhlmanii, Antiaris toxicaria* and *Sterculia appendiculata.* Currently it is harvested for fuelwood and building poles thus being under-valued, Due to its wood technical properties not known to users it is placed in royalty fee class V timbers. The objective of this study was therefore to determine and assess some basic physical and mechanical properties of *N. holtzii.* Compare the determined strength properties of *N. holtzii* with those from well known tree species. Use different combinations of the properties of *N. holtzii* obtained to assign suitable end uses and promote it for its utilization. Three mature sample trees free from visible defects were selected randomly. Each tree was sampled to produced three logs. Test specimens were extracted from the sample logs using the method by Larvers (1969). Physical and strength properties determination was carried out according to the procedure described in ISO 3131(1975) ISO3133 (1975) BS 373(1957, 1976) Larvers (1969) and Panshin and de Zeeuw (1970). The results showed that *N. holtzii* was found to have yellow timber that turns reddish brown on seasoning and the wood is fine textured. The average basic density is 593 kg m^{-3} Modulus of Elasticity 7,606 N/mm^{-3}, Modulus of Rupture 81 N/mm^{-2}, Work to Maximum Load 0.098 N mm^{-3}, Total Work 0.196 N mm^{-3}, Compression Stress 48.83 N mm^{-2}, Shear Stress 11.40 N mm^{-2} and Cleavage Strength 24.98 N mm^{-1}. These properties are within the acceptable range for the building and furniture industry. As many traditional timbers become scarcer, the timber of *Nesogordonia holtzii* should be promoted and is recommended as a substitute for *Afzelia quanzensis, Pterocarpus angolensis* and *Newtonia buchananii.* The resemblance in colour allows these timber species to be sold in one group.

Key words: Basic density – Tanga - *Olea hochstteter – Brachystergia* spp

INTRODUCTION

Wood is a single, but wonderful material that can be used in either raw form or processed into a number of products. It can be used in round form, split, sawn into lumber, sliced into veneer, chipped into particles, broken into fibers, ground into flour and broken down into a number of chemicals. Bryce (1967) summarized some of the uses of wood to be fuel for various applications, building boats, casks, dock and harbor works, marine pilling, flooring, furniture, fencing, greenhouse, joinery, packaging, pit wood, plywood, poles, pulp and paper and railway sleepers. Others include sport goods and tool handles, production of particleboards and chipboards, tools, machines and mills, carts, buckets, shoes, fuel and shipbuilding.

Different tree species differ substantially in their physical, chemical and strength properties of their wood. In utilization therefore, it is good to exploit fully, the properties of wood in order to assign a correct use to a given wood type. Formally, selection of tree species to a given use depended on experience of the user and availability of that tree species. These selected timber species were physically and mechanically tested leaving a great number of tree species not very much known to users. These are known as lesser-known species referring to a mixture of large number of timber species that are currently lesser known by users and therefore not easily acceptable in local and export markets. In most cases such species remain in the forest as waste after creaming operations (Bethel, 1984; Smith *et al*., 1994; Ishengoma *et al*., 2004). While a few well-known expensive timber species are harvested processed and utilized properly, some being utilized for purposes which other potentially suitable but far cheaper timbers could be utilized.

After most conventional timbers have been over-exploited these lesser-known species are now being put into use. There is now big demand of these species though locally, their properties are not known, which give problem in pricing and grading. According to Bryce (1967) selection of timber for specific use depends on four factors namely technical performance, cost, size and availability. The technical performance includes mechanical and physical properties. These include durability, movement, strength, stiffness and toughness, permeability and easy processing. In most cases the physical and mechanical properties used to assign the best use of timber are density, static bending, compression, cleavage, tension and shear.

The promotion of lesser known and lesser utilized tropical hard wood timber species for commercial utilization is important and will in the long term be of the interest of both timber producing and consuming countries in terms of seeking new ways of reducing pressure on the already degraded forest (Gymfi and Breese, 1994 in Ishengoma *et al*., 2000). On the other hand, in countries like Tanzania inadequate information on wood properties of these lesser-known and lesser-utilized tree species is a major limitation in their promotion and commercial utilization (Ishengoma *et al*., 2000).

If lesser-known timber could be utilized as noted by Ishengoma *et al.* (2000), a great volume of timber could be available for quality utilization or export since the few known species are already scarce if not depleted. It is likely that some of lesser-utilized species will become merchantable where more is known about them and this could reduce pressure on better-known species. It is therefore very important to conduct research on lesser-known and lesser-utilized species.

Lesser-known timber species are many and due to the decrease in the availability of traditional timber species, they need to be put into use. For wood to be used reasonably however, its physical and mechanical properties should be known. Without this knowledge, some of these timbers might be used in marine work while their durability is low, some in scaffolding while their value is high that permit them to be used in furniture and high value works or their mechanical properties are inferior therefore safety hazardous to areas of their application.

Nesogordonia holtzii subsp. *holtzii* (Moss) Capuron is one of the lesser-known and lesser-utilized timber species in Tanzania, normally found in dry lowland forest and coastal thicket at altitudes of between 1 and 1,500 masl. This species is known by such vernacular names as Mkomba Mwitu (Zigua, Nguu), Mnofi (Ha) Mheru and Mrunza (Haya). *N. holtzii,* belonging to the family of Sterculiaceae is an evergreen tree with straight and buttressed bole 8 – 30 metres high.

Currently, *Nesogordonia holtzii* is used in woodfuel and building poles thus being under-valued and placed in class V timbers, which are not commonly commercially used. Their under-utilizaton is largely due to lack of information on their physical and mechanical properties. If these properties are known and found to be more suitable than the traditional timber species, they can either complement or substitute them.

Knowing the basic physical and strength properties of this species, and availing this information to the timber stakeholders may help reducing the scarcity of timber, relieving pressure to the traditional timber species and therefore promoting their regeneration and reducing poverty through the increased market values of *N. holtzii*.

OBJECTIVES

Main objective

The main objective of this study was to determine some physical and mechanical properties of *Nesogordonia holtzii* a lesser-known and lesser-utilized timber species from Tanzania.

In order to meet the objective of this study, the timber of *N. holtzii* was assessed to determine the following physical properties; colour and texture, basic density. Further the mechanical properties of the timber were assessed including static bending, modulus of elasticity, modulus of rupture, work to maximum load, total work, compression parallel to the grain, shear strength and cleavage strength

(c) To determine and assess. The relationships between the mechanical properties and basic density and strength properties were also assessed and uses assigned accordingly.

MATERIALS AND METHODS

Study area description

The samples were collected from general land bordering Kilindi Catchment Forest Reserve in Tanga Region, located between latitudes $5^{o}33'$ - $5^{o}40'$ S and longitudes $37^{o}33'$ - $37^{o}36'$ E. The altitudinal range of this area is 760 to 1,520 metres above sea level. The access to this forest is from either Handeni or Turiani via Kwediboma.

The soils in the forest are black sand loam, rich in humus on gneissic basement rock, being deep in valley and shallow on ridges. According to Lovert and Pòcs (1993), the area receives rainfall ranging from 1,500 – 2,000 mm per year on the eastern side and 1,000 – 1,200 mm per year on the western side. Temperatures are estimated to be 24^{0}C maximum (February) and 19^{0}C minimum (July).

The forest is of the eastern arc type, rich in species of restricted distribution with main vegetation type of riverine to lowland forest and montane to sub-montane forest with increasing altitude (CELP, 2001). Species found in association with *Nesogordonia holtzii* were *Newtonia buchananii, Allanblankia stuhlmanii, Albizia versicolar, Antiaris toxicaria, Sterculia appendiculata, Pterocarpus sp*, and *Tabernamontana ventricosa*.

Data collection

Samples were collected from three mature and defect free trees of *Nesogordonia holtzii*, objectively selected after thorough observation of their physical appearance. These represented small, medium and large tree sizes. The trees were felled and their diameters at breast height (dbh) were measured using a diameter tape and their total heights were measured using a measuring tape.. Three billets, each measuring 1.5 m length were cut from breast height upwards for each tree felled. The billets were hauled to Handeni town to be sawn to central planks before being transported to Department of Wood Utilization of Sokoine University of Agriculture for further processing. The cants were re-sawn into 30 mm x 65 mm x 1,500 mm planks from the pith left and right towards the bark. These planks were then numbered and labeled sequentially to show the position of extraction and direction of sawing and stacked for drying until the moisture content was around 12 ~~15~~ %. The planks were then re-sawn and planed down to 20mm x 20mm x 1500mm sticks/scantlings from which the test samples of different dimensions for various wood properties were extracted.

Physical properties

Moisture content

Determination of moisture content of the test samples was done according to ISO 3130 (1975), employing oven-dry method. Adjustment of strength values for test specimens with moisture content lower or more than 12 % was done according to Desch (1981).

Colour and texture

The colour of the timber of *Nesogordonia holtzii* was determined visually after felling and extraction of cants and also before and after seasoning the specimens in the laboratory. The texture was also determined visually and supplemented with feeling by hand the fineness of the planed surface of the timber.

Basic density

For determination of basic density, 50 mm wood test samples were extracted from each scantling before drying. The basic density was determined according to the method described in ISO 3131 (1975).

Mechanical properties

The planks were first air dried then converted into scantlings/sticks of 20 mm x 20 mm x 1,500 mm from which different test samples of various dimensions for different wood properties were extracted as shown in table 1.

The different tests for mechanical properties were carried out following the procedures described by BS 373 (1957; 1976), Lavers (1969), Panshin and de Zeeuw (1970), ISO 3133 (1975) for testing clear wood specimens. These tests were Static bending from which the Modulus of elasticity (MOE), Modulus of rupture (MOR), Work to maximum load (Wmax) and Total work to failure (Wtotal) were determined. Others are Compression strength parallel to grain, Cleavage strength and Shear strength parallel to grain.

Table 1Wood sample dimensions and count used for strength properties determination for *Nesorgodonia holtzii* from Kilindi district, Tanga Tanzania

Type of test	Sample dimensions (mm	Sample count
Static bending	20 x 20 x 300	54
Shear parallel to grain	20 x 20 x 20	54
Cleavage	20 x 20 x 45	54
Compression parallel to grain	20 x 20 x 60	54

Data analysis

The obtained data were summarized and subjected to the Excel Computer program package for analysis. The tools used were descriptive statistics and analysis of variance (ANOVA) for determination of variation between and within trees. Also, regression analysis was used to establish relationship existing among wood basic density and the mechanical properties.

RESULTS AND DISCUSSION

Physical properties

Colour and texture

The colour of the timber of *Nesogordonia holtzii* is pale yellow, which turns reddish brown upon drying. It produces fine texture and attains good finish in planing. The timber is easy to work because has straight grain and does not split when nailed. These properties are suitable in some uses such as joinery, furniture making and cabinet manufacture.

Basic density

Nesogordonia holtzii has a basic density ranging from 500 to 695 kg m^{-3} with average of 593 kg m^{-3} as shown in Table 2 below. As noted by Chudnof (1980), Dinwoodie (1980) and Desch (1981), different timbers vary in density from 160 to 1,250 kg m^{-3}. The obtained average density of *N. holtzii* is equal to that of *Ocotea usambarensis* and almost equal to that of *Afzelia quanzensis* (577 kg m^{-3}), *Khaya anthotheca* (545 kg m^{-3}) and *Newtonia buchananii* (561 kg m^{-3}), documented by Lavers (1969). According to Panshin and de Zeeuw (1970), this timber is heavy. With this range of density, it can be used in boat internal fittings, batons and other structural uses where moderately high density is a desired property.

Mechanical properties

The results for each mechanical property were adjusted to a moisture content of 12 % to allow comparison to be made with results reported by other researchers elsewhere.

Static bending

From Table 2, the timber has MOE of 7,606 N mm^{-2}, MOR of 81 N mm^{-2} and Work to maximum load and Total work to failure of 0.098 mm Nmm^{-2} and 0.196 mm Nmm^{-3} respectively. These values show that the timber can be subjected to high load without failing easily a characteristic that is sought in many structural applications like in construction and joinery.

Table 2 Summary of wood properties of *Nesogordonia holtzii* timber from Kilindi district, Tanga Tanzania

Wood Property	Value			Remarks
	Minimum	Maximum	Mean	
Basic density kg m^{-3}	500	695	593	Moderately heavy
Modulus of elasticity N mm^{-2}	3,856	12,123	7,606	Strong
Modulus of rupture N mm^{-2}	45	115	81	Strong
Work maximum mmN mm^{-3}	0.026	0.209	0.098	Strong
Work Total mmN mm^{-3}	0.057	0.409	0.196	Strong
Shear Stress N mm^{-2}	5.82	17.04	11.4	Weak
Compression stress N mm^{-2}	34.89	53.34	48.83	Strong
Cleavage N mm^{-1}	12.50	34.38	24.98	Exceptionally strong

Compression parallel to grain

The resistance to compressive forces parallel to grain for *Nesogordonia holtzii* is 48.83 Nmm^{-2} which is close to that recorded by Bryce (1967) for *Eucalyptus globulus* (49.7 Nmm^{-2}), *Newtonia buchananii* (50.10 Nmm^{-2}), *Olea hochstteteri* (48.80 Nmm^{-2}), *Maesopsis eminii* (50.00 Nmm^{-2}) and most *Brachystergia spp.* (47.8 – 60.00 Nmm^{-2})

This property makes this timber species candidate in poles and mining props where loading is normally parallel to the direction of grain. In this aspect, *Nesogordonia holtzii* is superior to *Milicia excelsa* (38.97 Nmm^{-2}) and *Khaya anthotheca* (42.41 Nmm^{-2}) and inferior to *Afzelia quanzensis* (69.20 Nmm^{-2}).

Shear strength

Nesogordonia holtzii has average shear force of 11.40 Nmm^{-2} which according to Bryce (1967) is similar to that of *Maesopsis eminii* (11.30 Nmm^{-2}), *Pinus patula* (14.60 Nmm^{-2}) and *Sterculia quinqueloba* (11.50 Nmm^{-2}). This property is highly sought in designing of joints in construction work (Ishengoma and Nagoda, 1991). The values for *Nesogordonia holtzii* indicate the species to be weak in this aspect therefore not suitable for joints but excellent for veneer.

Cleavage strength

Nesogordonia holtzii timber has average value of cleavage strength of 24.98 Nmm^{-1}. This value is considerably high when compared to values recorded by Bryce (1967) for the commercial timbers of Tanzania, in which the maximum of 21.60 Nmm^{-1} was recorded for *Olea hochstteteri*. Other species, which recorded average cleavage strength of 20 Nmm^{-1}, are *Diospyros abyssinica*, *Erythrophleum africanum* and *Sclerocarya birrea*. This indicates that, the timber of *Nesogordonia holtzii* splits with much more difficulty therefore, will resist splitting on seasoning and in furniture making it will show high nail holding capacity. This timber is also suitable for shuttles, rollers and pulley sheaves.

Within tree variations of the wood properties

Table 3 gives a summary of within tree axial and radial variations of the studied properties.

From Table 3 above, basic density, MOR, Work to maximum load and Total work decreased from bottom to the top of the tree bole ($p \leq 0.01$) and Compression strength also followed the same trend ($p = 0.04$). This indicates that the heaviest and strongest timber in the above observed properties for *N. holtzii* is found in the first log from the base and the lightest and weakest timber is in the last log near the tip.

Table 3 Within tree axial and radial variations of basic density and some mechanical properties of *Nesogordonia holtzii* from Kilindi district, Tanga Tanzania

Wood property	**Position in the tree bole**			
	Bottom (Near pith)	**Middle (Mid radius)**	**Top (Near bark)**	**p-value**
Basic density kg m^{-3}	612 (594)	590 (599)	576 (588)	<0.01* (0.541)
Modulus of elasticity N mm^{-2}	7,563 (8,427)	8,300 (8,206)	6,954 (6,252)	0.06 (0.03)**
Modulus of rupture N mm^{-2}	90.5 (88.0)	80.0 (85.2)	73.5 (72.7)	<0.01* (0.12)
Work maximum mmN mm^{-3}	0.12 (0.10)	0.09 (0.10)	0.08 (0.10)	<0.01* (0.66)
Work Total mmN mm^{-3}	0.25 (0.23)	0.195 (0.192)	0.147 (0.187)	<0.01* (0.59)
Shear Stress N mm^{-2}	12.13 (11.79)	11.16 (11.86)	10.92 (10.55)	0.48 (0.95)
Compression stress N mm^{-2}	50.7 (50.7)	48.1 (49.6)	47.7 (44.7)	0.04** (<0.01)*
Cleavage N mm^{-1}	24.74 (23.82)	23.96 (26.06)	26.23 (24.65)	0.22 (0.60)

Subheadings and values in parentheses indicate radial variations, the rest are axial variations

* Statistically significant ($p \leq 0.01$), ** Statistically significant ($p \leq 0.05$).

For MOE and Shear, the strength decreased however, the difference was not statistically significant. Cleavage strength showed the opposite trend nevertheless, again the difference was not statistically significant.

In the radial direction, only Compression and MOE strength showed to be adversely affected by the position in the tree, from pith to bark ($p \leq 0.01$ and $p = 0.03$ respectively). There were no significant differences in the means of the other studied properties.

The above observed trends are a clear evidence of the influence of density on the mechanical properties. Desch and Dinwoodie (1996) reported that most mechanical properties of wood are positively correlated to density. The radial variation of density though insignificant, indicates that *Nesogordonia holtzii* is diffuse-porous wood. Desch (1973) observed that in this group of woods, there is at first a slight increase and then a gradual decrease in density, from pith towards bark.

The observed axial variation in density for *N. holtzii* follows one of the five patterns reported by Desch (1973) for different species.

Relationship between basic density and strength properties

Axial direction

The results presented in Table 4, reveal that except for MOE and cleavage, there is a strong relationship between basic density and most strength properties in the axial direction. This is shown by the coefficient of variation, R^2 that indicates a linear relationship between basic density and strength properties and the p-value for significance level. Basic density therefore can be used to approximate strength properties in the axial direction

Radial direction

In the radial direction though slightly positive, most parts showed very weak relation of basic density and mechanical properties. This agrees to some extent with Ishengoma and Nagoda (1991) that the relationship does not exist if a number of species are considered together and not singly.

Table 4 Axial linear correlation of density and strength properties of *Nesogordoni holtzii* timber from Kilindi district, Tanzania

Strength property	**Regression Equation**	R^2	**p-value**
Modulus of elasticity	$Y = -51.31 + 12.919\chi$	0.12	0.02*
Modulus of rupture	$Y = -202.39 + 0.4786\chi$	0.99	$\leq$0.01**
work maximum	$Y = -0.59 + 0.0012\chi$	0.99	$\leq$0.01**
Compression	$Y = -3.13 + 0.0877\chi$	0.92	0.03*
Cleavage	$Y = 45.87 - 0.0353\chi$	0.30	0.06
Shear	$Y = -9.26 + 0.0349\chi$	0.96	0.08

* Statistically significant at $p \leq 0.05$, ** Statistically significant at $p \leq 0.01$

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Nesogordonia holtzii timber is reddish brown and has fine texture when planed. The density of the timber is moderately high (593 kg m^{-3}) and is comparable to the timber of *Ocotea usambarensis*, *Afzelia quanzensis*, *Khaya anthotheca* and *Newtonia buchananii*. The timber has strong mechanical properties except for shear strength of 11.4 N mm^{-2} which is weak and exceptionally strong in cleavage with strength of 24.98 N mm^{-1}.

Stiffness and bending strength of this species, measured by MOE and MOR respectively resemble that of many species like *Milicia excelsa, Olea hochstetteri, Brachystegia spp.*, *Sterculia quinqueloba* and *Maesopsis eminii*.

The timber is also strong in compression parallel to grain (48.83 N mm^{-2}) comparable to *Olea hochstetteri* and *Maesopsis eminii*. In this aspect, *Nesogordonia holtzii* is stronger than *Milicia excelsa* and Sterculia *quinqueloba.*

Within tree variations in basic density and the studied mechanical properties show a decrease in the values in the axial direction, from bottom to top of the tree bole. In the radial direction, the variations are statistically insignificant except for MOE and Compression which decreased from the pith towards the bark.

Recommendations

The reddish brown colour of the timber of *Nesogordonia holtzii* and its fine texture is important for making quality furniture where appearance is needed. In this aspect, *N. holtzii* is recommended as a substitute of *Afzelia quanzensis, Pterocarpus angolensis* and *Newtonia buchananii.* The resemblance in colour allows these timber species to be sold in one group.

Nesogordonia holtzii has average properties that resemble many traditional timbers. It is recommended therefore, to replace many of them in uses and serve that particular application. The uses include most joinery, paneling, veneer, cabinet and furniture making and poles and props in building construction and mining works. This timber is also suitable for shuttles, rollers and pulley sheaves.

For applications where dense and strong wood is a prerequisite, the timber from *N. holtzii* should be extracted from the bottom portion of the tree bole. This species should be promoted from the current class V to class I, fetching more value and more royalty fee to the government.

Since *N. holtzii* is still a lesser known and lesser utilized species it should be promoted and domesticated as an agroforestry tree in areas where climatic and soil conditions are favourable, to increase its products and local people's income which contribute to the country's efforts to poverty alleviation.

REFERENCES

British Standard B S373 (1957) Methods of testing small clear specimens.

Bryce, J.M. (1967). Commercial timbers of Tanzania. Forest division, Ministry of Agriculture and Cooperatives, Utilization Section, Moshi Tanzania 139p

Chudnof, M. (1980), Tropical timber of the world Forest product Laboratory, U.S Department of Agriculture.

Desch, H.E (1973) *Timber its Structure and Properties.* Unwin Brothers Ltd Surrey 172 p.

Desch, H.E (1981) *Timber its Structure and Properties* 6th Edit MacMillan Press Ltd London 410p.

Desch, H.E. and J.M. Dinwoodie (1996). *Timber Structure, Properties, Conversion and Use.*

Dinwoodie J.M. (1980). Timber. Its nature and behaviour international student edition Van No Strand Reinhold.

Hilm, T., Midon, M.S, Pun, C.Y, Kasby, N.A.M, Mohd, R. (1996) hand book of Structural timber design and simple solid members. FRIM technical information hand Book No. 6 Kuala Lumpur 147 pp.

Ishengoma, R.C., Gillar, P.R., Amartey, S.A., Makonda, F.B.S. and Hamza, K.F.S. (2000), Important Physical and Mechanical Properties of *Albizia amara* A lesser Utilizedtree Species in Tanzania. The Journal of Forestry and Nature Conservation Vol 73. SUA Morogoro, Tanzania.

Ishengoma R.C and L. Nagoda (1991). Solid wood:: Physical and strength properties, Defects, Grading and utilization as fuel A Teaching Compendium Faculty of Forestry, Sokoine University of Agriculture, Morogoro, Tanzania

Ishengoma R.C., Gillah, P.R, Buyeya, J. and Kitojo, D.K., (2004) Assessment of Physical and Strength Properties of *Fauzia saligna* and *Bridelia micrantha*.The l esser known and Lesser-used Timbers from Iringa, Tanzania, in *Journal of the Tanzania Association of Foresters* Vol 10 July 2004 94 – 98 p

Ishengoma, R.C, Ringo, W.N, Iddi, S (1992), Research Priorities in Wood utilization in Abel S.W. Mgeni, A. S. M,

Chamshama, S. A. O, Iddi, S, O O'kting'ati , A proceedings of a joint seminar/workshop on Forestry research in Tanzania" Under Sokoine University of Agriculture and Agricultural University of Norway Cooperation ,Morogoro Tanzania 26th– 30th November 1990. Forestry Record No 53. 68-73pp

ISO 3131 (1975). Wood determination of density for Physical and Mechanical Tests. 1st edition, (UDC 674.03:531.754). International Organization for Standardization, Switzerland.

ISO 3133 (1975). Wood determination of ultimate

strength in static bending. First edition (UDC 674.03:539.384) International organization for standardization. Printed in Switzerland.

Koch, P. (1972) Utilization of the southern Pines U.S. department of Agriculture and Forest service Washington DC..

Kollman, F.P and Wilfred A Cote J.R. (1968) Principles of wood science and Technology, solid wood Springer Vedag New York Inc 1968

Lavers, G.M. (1969), strength properties of Timbers Department of the Environment Forest product Research Bulletin No 50 62pp. London.

Lovert, J.C and Pòcs. (1993) Assessment of the condition of the catchment forest Reserve:Catchments Forestry Report 9:3, Dar es Salaam.

Mahonge C.P.I (2000) Assessment of wood quality of *Grevillea robusta* (Cunn) and *Cordia africana* (Lam) Grown under Agro forestry in Arumeru, Tanzania. A Dissertation submitted in partial fulfillment for the degree of Masters of Science in Forestry at the Sokoine University of Agriculture.

MNRT. (1998) Tanzania Forest Policy, Forest and keeping division, Ministry of Natural Resources and Tourism Dar es salaam 38 pp.

Pun, C.Y. (1977) Timber design handbook Malayan Forest records No 42

Siemon, G.R (1979) Queensland research Note No 29 department of Forestry.

The Centre for Ecology Law and Policy (2001). *The Management and Ecology of Tanzanian Forests*. The University of York, UK.