TANZANIA FORESTRY RESEARCH INSTITUTE
(TAFORI)

SIX DECADES OF FOREST UTILISATION RESEARCH IN TANZANIA

A SYNTHESIS

(1st EDITION FINAL COPY)

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Table of Contents

Introduction

Forest Utilisation research is one of the oldest research themes in Tanzania. Already in 1932 timber test methods had been introduced in Tanganyika from England. Forest utilisation research was carried out under the then Utilisation Section of the Forest Division. Much work on Tanzanian timbers had also been done by the Forest Products Research Laboratory, in the UK, Forest Products Institute in South Africa and the Division of Forest Products in Australia. The first book on Commercial Timbers of Tanzania was published by J. M. Bryce (1967). After the formation of TAFORI in 1980, all forest utilisation research was under the Moshi Timber Utilisation Research Centre and since then much work has been done on lesser marketed timber species. This additional information enabled the institute to revise the Commercial Timbers of Tanzania book in 2000 (second edition) and 2003 (third edition) respectively by A. W. Chihongo.
This synthesis presents work done since the inception of timber utilisation research both under the Forest Division and after formation of TAFORI. The information used in this synthesis was obtained from Tanzania Timber Utilisation Research Technical Notes, Information Notes, Series and Reports. It is organised in eight parts namely; machining and mechanical properties, peeling and gluing characteristics of various tree species, wood preservatives tests, durability tests, timber seasoning (movement of timber), energy research, forest protection and non timber forest products. The main aim of this synthesis is to provide stakeholders with basic information on forest utilisation research in Tanzania and help our clients to access the detailed information to solve their problems related to forest products.

PART I

Wood machining and mechanical properties

Timber engineering and wood products development is an important component in forest utilisation as it determines the grade of timber produced which reflects the market price. Since the inception of the timber utilisation research section of the Forest Division, research has been done on timber machining and other mechanical strength properties. About 150 timber tree species out of more than 250 species in Tanzania have been studied for their machining and strength properties. There has however since then been advancement in technologies and indigenous knowledge in timber engineering. Currently much of lumber is produced through pit-sawing and mobile sawmilling. This has effect on the quality of timber produced. There are increased use of round small size timber, some from left over branches for making household furniture and other items. There is therefore an urgent need to carry out timber strength tests in round wood forms for most of the species.

The results of wood and machining tests are presented in Tanzania Timber Utilisation Technical Notes, hereafter referred to as Technical Notes for each species available in Moshi Utilisation Research Centre. The past work on wood machining and strength properties resulted into a revised book of the Commercial Timbers of Tanzania in 2000

(Chihongo, 2000; 2nd edition) and in 2003 (Chihongo, 2003; 3rd Edition). Readers are advised to consult this book for more information on timber species. Wood properties of some commercial timbers of Tanzania are presented here for easy reference.

J. M. BRYCE; **Utilisation Division. An Experiment with Mechanical Restraint in Seasoning (**technical Note No. 24)
In seasoning timber it is generally recognised that careful stacking and the placing of weights on top of the stack will minimise distortion. These practices are a form of mechanical restraint tending to hold the boards in shape, and since distortion usually increases towards the top of the stack it will as a rule be reduced as the force of restraint is increased.

Timber held in shape during seasoning sets in or near that shape, but on release from the pile there is a tendency to "creep", that is the timber distorts in the same way, but not to the same degree, as when dried free of restraint. The ultimate distortion is usually considerably less than that in boards dried singly or small unweighted stacks.

FLAMWELL C.T.; **Utilisation Division, The Machining Properties of *Cupressus Lusitanica*** (Technical Note No. 21)

This report is based on the results of tests on trees collected from the Narok Plantations, Mt. Meru, Arusha District. The trees were thinning of an average diameter of fifteen inches at the butt.

The timber was air dried to 12% moisture content, and its density then averaging 29 1b per cubic foot. Knots average 2.5 in per surface foot.

BRYCE J.M. BRYCE; **Utilisation Section. Diffusion Impregnation Experiments with Tanganyika Timbers** (Technical Note No. 32)

Treatment schedules were selected more or less arbitrarily for a preliminary series of diffusion tests on some Tanganyika timbers. The depth of penetration of borax was determined by spot testing, and a limited number of chemical analyses were carried out by Borax Consolidates Ltd; or penetration, or both, even where long immersion and storage times were employed. The partial success of some of the momentary immersion treatments indicates the need for the use of solution concentrations higher than 15% boric acid equivalent, and immersion periods probably well in excess of one hour. The results of the tests have shown the minimum brock-strcking times needed for each species.

One of the purposes of the tests was to attempt to devise treating schedules for Brachystegia sleepers. In view of the limited success of both the borax and asmose treatments this aim has not been achieved. A more comprehensive series of experiments is being undertaken by the Division of Forest Products, C.S.I.R.O., Australia.

UTILISATION SECTION; Cypress **Studies Sawmill Recovery and Bark Percentages** (Technical Note No. 39)

100 22-year old *Cupressus lusitanica* trees grown on Mount Meru, Tanzania, were tested for bark percentage at various heights in the standing tree. They were then sawn into logs, and the bark percentage calculated by log sizes. Finally the logs were sawn and the lumber recovery percent calculated for seven size classes of logs.

Wood properties and utilization of *Acacia albida* Series No. 2 1957

Acacia albida is locally common on alluvial soils and is often gregarious where the water table is near the surface. The heartwood is pale yellow pale creamy brown in colour not clearly differentiated the lighter sapwood of medium density. As compared to Podocarpus it is 30% weaker in maximum bending strength properties, 25% less stiff and 40% weaker in compression. Boards and planks spring and twist within an hour or two of cutting, and degrade during seasoning in severe. The timber is difficult to saw in the larger sizes because of its tendency to bind the saw. The irregularity of the grain causes pick up in planing. The wood in contact with the ground has a life of less than 6 months. The wood is perishable. It is attacked by blue stain when sawn must be dipped to fungicide before stacking. It is easily attacked by wood borers. To increase durability the wood can treated using chemical preservatives and complete penetration of creosote in obtained in both open tank and pressure treatments

Wood properties and utilization of locally grown *Pinus patula* and *P. radiata* Technical Note NO. 22 1959.

Investigations were done in conjunction with Kenya Forest Department into the properties of *P. patula* and *P. radiata*.

K. MALDE; **Eucalyptus Maidenii – Properties and Utilisation** (Technical Note No. 42)

Eucalyptus are the exotic broad-leaved species brought to Tanzania before the end of the last century. They are grown in small areas in most parts of Tanzania. The following regions have Eucalyptus maideni grown in small plantations (some have as much as 200 hectares under E. maideni): Arusha, Iringa, Kigoma, Kilimanjaro, Lake Regions (around Lake Victoria), Mbeya, Morogoro, Mtwara, and Tabora.

Eucalyptus maideni has been mainly used for poles and as fuelwood and not great deal in sawn form. Medicinal oils can be obtained from its leaves.

Wood properties and utilization of *Baikiaea insignis*, 1961

The wood is pale pinking-brown when freshly cut turning grayish brown on drying, with darker streaks, hard and heavy, with straight grain and medium texture. The wood has distinct growth rings. It dries moderately rapidly with a tendency to distort. This tree has strength properties well above average, for heavy construction compared with those of *Brachystegia spiciformis*. The wood is moderately difficult to saw, owing to the high

density. Tends to pick up in planing with standard knives but can be surfaced satisfactorily at low feed speeds, moulds well drills and mortises clearly, difficult to nail and liable to split. It is moderately resistant to preservative treatment and has service life of 1-2 years.

Wood properties and utilization of *Brachystegia spiciformis*

The sapwood is 5.1 to 10.6 cm wide pale cream or white, distinct from the heartwood. The heart wood is variable in colour, but usually pale brown. Growth rings marked by narrow bands of terminal parenchg vessels moderately large visible to the nacked eye. The wood dries very slowly with appreciable surface checking and some distortion and end splitting. Kiln drying of 2.5 cm materials requires about 4 weeks. The timber is hard to saw and work causing tools blunt. The interlocked grain is liable to tear in planing and cutting. The molding properties are poor. Drills feed easily and clear well but severe breaking occurs at unsupported exist. Clean and accurate mortises can be made with the chain mortise but square chisel require considerable efforts even in the smaller sizes. The nailing properties are very poor. Preboring is needed. The timber is not resistant to decay so requires treatment. It is however extremely resistant to preservatives. The heartwood is untreatable but the life of railway sleepers can be doubled by incision and pressure impregnation by creosote. Slight surface penetration can protect timber against decay. Sleepers are sawn with maximum proportion of sapwood so as to improve penetration. Normally used in railway sleepers, cheap furniture and low grade building construction mosaic parquetry shuttering. Other uses include paddles, mining tools handles and ladders.

UTILISATION SECTION; **Properties of Erica Arborea on Mr. Kilimanjaro (A study of its suitability for the manufacture of tobacco pipes)** (Technical Note No. 31).

The so-called briar – (or brier) wood from which tobacco pipes are made is obtained from the roots of *Erica arborea* L., Southern Europe being the major source of supply. *Erica arborea* occurs on the mountains of East Africa, and on Kilimanjaro is fairly abundant on the eastern slopes between 7000 and 9000 fest altitude. Pipe manufacturers have from time to time shown interest in the potentialities of East African briar-wood, and it is known that tests were done by German investigators over 50 years ago. No record of tests is available locally but it is believed that they showed and also in Tanganyika when samples were on later occasions pronounced unsuitable by United Kingdom manufacturers. It has been suggested that in some of the earlier tests the methods of extraction and seasoning may not have been carefully enough controlled, and some additional work was needed if only to resolve such doubts.

The question was recently re-opened as a result of enquiries by the Tanganyika Meerschaum Corporation, a firm engaged in the large-scale manufacture of both meerschaum and briar pipes. Factual information proved to be lacking, so an investigation was undertaken in co-operation with the firm, who specified the method of harvesting and conversion and supplied seasoned ebauchons of European briar for comparative tests.

Machining properties of *Albizia antunnesiana* Technical Note No. 16 1959

The timber of *A. antunnesiana* is reddish – brown with medium to course texture and irregular grain. The sawdust is irritating to the nose and eyes. The experiments were based on standard wood working tests stipulated in Technical Note no.7. The timber is good for furniture and general building purposes. However the timber is difficult to nail without splitting, thus requires pre-boring.

Machining properties of Julbernadia globiflora Technical Note No. 17

Different machining properties such as rip sawing, planning, cross cutting, band sawing, spindle molding, turning, boring, mortising and nailing were carried out using standards stipulated in Technical number 7. Rip sawing with using saws with 40-54 teeth at 38 feet per minute feed speed gave satisfactory results in both heart wood and sap wood. Planing at reduced speed of 20 feet per minute gave satisfactory results. While crosscutting is easy with all types of cross cutting saws, the timber is some what difficult to bore. The timber is therefore difficult to nail and requires pre-boring.

Machining properties of *Cassearia battiscombei* technical Note NO. 18 1959

The timber cuts freely and can be fed easily with all saw types producing very fine sawdust. Saws with 64 and 100 teeth give good finish. Nails can be driven easily into the timbers and its holding power is good.

Machining properties of *Makharanga conglomerata* Technical Note No. 19 (1959)

Timber is pale brown with somewhat wavy grain. The timber is easily planed and gives good finish with standard knives of 30^0 cutting angle. The timber can be nailed well and holds nails.

Mechanical properties of *Cuppressus lusitanica* technical Note No. 21 (1959)
Timber cuts easily in rip sawing with all the saw types and give the best finish. The timber can be planned easily to good finish with the standard 30^oknives. Cross cutting with 64 and 110 teeth saws give best finish and clean cuts. The timber is good for all types of construction needs and furniture.

The wood properties and uses of *Ficalhoa laurifolia* (1966)
The sapwood is not always distinguishable. The timber is light brown/reddish with no variation in color, heavy, moderately hard with fine texture, straight grain and no figure.
The strength properties of Ficalhoa are comparable with those of *Pterocarpus angolensis*. It has approximately the same bending, compression and shearing strength and the same resistance to splitting. The timber has high resistance to abrasive action. The wearing qualities prove suitable for both general utility and decorative floors subjected to heavy pedestrian and light industrial traffic. All standard saw types cut easily in both green and

dry timber. The sawdust is very fine. The timber planes easily to a good finish with the standard 30^0 knives. The moulding properties are excellent. The timber splits easily on drilling. It dries very slowly and requires careful stacking due to its high shrinkage. Treatment by incision gives no improvement in the durability of the heart wood with both types of preservatives. It is suitable for interior work.

The wood properties and uses of *Cassipourea malosana* (Pillarwood) (1960)
The study was conducted using the combination of different test methods as stipulated in Technical Note No 7 and Leaflet No 47. The wood is cream coloured to pale brown timber It is heavy, moderately hard strong and tough. It seasons rapidly, have high differential shrinkage, perishable, difficult to saw. Used mainly as excellent flooring timber and turnery.

The wood properties and uses of Diospyros abyssinica (Msambu) (1960)
Some of the test methods are stipulated in Technical Note No 7 and others in leaflets No 47. Different properties and uses were studied and found that the wood has a pale, featureless, fine-grained timber. The wood is very heavy with good strength properties except in toughness. Air dries slowly. For kiln drying low temperature are essential, but drying is fairly rapid. The timber is perishable but treatable by pressure processes. Main uses of this species are in manufacture of hoe, pick and spade handles; also in manufacture of golf club heads.

The utilisation properties of second growth Cephalosphaera usambarensis, Technical Note No 27 (1961)
The species has butt rot amounting to about 12% of the volume of the tree. The sound sap wood has a lower density than mature camphor but is usable for low grade work. The main use of the timber is in shuttering, cheap furniture and joinery and can be peeled for plywood.

UTILISATION SECTION**; Strength Properties of Meru Cypress (*Cupressus lusitanica* Mill)** Technical Note No. 36 (1966)

The older Cypress plantations in Tanzania generally produce a fairly low-grade, knotty timber of average density. The strength tests reported in this paper were made on material from a 27 – year-old plantation at Narok, on Mr. Meru in Arusha District, and the results show the strength properties to be almost identical with those of Kenya-grown Cypress about the same age)(1)

UTULISATION SECTION; **Further Reflections on the Properties of Second Growth Camphor (O. usambarensis) Information Note No. 4.**

Sixteen trees of second-growth Camphor, collected from the Mkusu Forest Reserve, Lushoto, were examined for comparison with a consignment from Barankata.

All the trees had a greyish-brown core with an irregular margin suggestive of fungal attack, and some cross-sections showed the radial flecks described by Mr. Preston as "brown streaked rot."

Wood in the discoloured core was denser than that in the Barankata trees, was 10 – 20% lighter in weight than the sapwood, and increased in density from the pith outwards. There was little variation in bending strength across the diameter, but compression strength tender to rise from pith to bark. No sharp change in the properties was observed at the boundary of the core. Impregnation tests indicated the presence of true heartwood.

It was concluded that the discoloured core represents a combination of heartwood and fungal stack, the latter not having developed so far, at this stage, as seriously to affect the properties of the wood.

The timber is suitable for light construction and joinery. The logs peel easily and the young trees would be acceptable to the plywood industry provided heart rot does not develop further.

The wood properties and uses of *Allanblackia stuhlmannii* (Mkanya, Msambu) (1961)
The timber heartwood is dark brown to purplish brown, moderately heavy and hard, with medium texture. It polishes well and is suitable for furniture and joinery; the sapwood is a light grey brown moderately heavy but not hard with medium texture and straight grain. Saws and machines easily, seasons fairly slowly and kiln dries rapidly with high differential shrinkage and a tendency to distort. Movement in changing atmospheric humidity is large. Perishable but treatable by open tank and pressure methods

Some work on determining physical and mechanical properties of chipboards was carried out by the Moshi Centre, but not reported in the Commercial Timbers of Tanzania book as reported by K. K. CHINULA (1979) **Technical Note No.?** on **Physical and Mechanical Properties of Chipboard Manufactured with Black Wattle Tannin Glue.** Physical and Mechanical properties of chipboard manufactured with black wattle tannin glue were determined in accordance with the American Standard D. 1037: 1964 with the exception of resistance to impact property. The panel impact test had to be employed to determine the impact resistance property. The use of black wattle tannin glue was recommended as the material was locally available from wattle processing factories.

J. F. HUGHES**; Sawing of pillar wood (*Cassipourea malosana*),** Technical Note No 2 (1957)
Different saw types and settings of teeth, clearance and gauge suitable for *C. malosana* are presented.

UTILISATION SECTION**; The sawing of pillar wood (*Cassipourea elliottii*),** Technical Note No 2 (1957)
This Technical Note present saw type for the species in sawing and re-sawing. The saw types suitable for this species are also recommended for *Podocarpus* spp.

UTILISATION SECTION; **Flooring Timbers,** Series No ? (1960)
It is argued that almost any kind of wood if properly dried and processed will make a floor, but where the wearing qualities and appearance are of importance, the choice of the timber must be considered carefully. Most soft woods have a good utility value in wood block or in strip form, but they are less decorative than hard wood and do not have the natural resistance to abrasion. Hence the choice of any particular timber will be governed by the type of building, type of traffic and the expected severity of wear, costs and availability.

UTILISATION SECTION**; Rim Speeds for Circular Saws Sawmill**, Series No. 8 (1962)
The study was conducted to determine rim speed for circular saws sawmill and the results indicated that for swing the dense timbers such as *Brachystegia*, and abrasive timbers, rim speeds of less than 10,000 f.p.m. are recommended. Saws performing satisfactorily when run at very low rim speeds provided the low feed speeds also; but at a rim speed of 6,000 f.p.m. there is possibility of over loading the teeth at feed speeds of more than 80 f.p.m.

C. T FLAMWELL; **Kupasua Mbao** Technical Note No. ? (1964)
A small text book prepared purposely for leading people who want to engage in timber sawing business, to know exactly what is required, how to monitor the business so as to succeed, also selection of saws, mobile mills, maintenance, log supply and sales of timber.

UTILISATION SECTION; **Nail withdrawal resistance of some Tanzania timbers**, Technical Note No 37 (1966)
The efficient of a nailed joint depends on the wood, the nail and conditions of service. The harder and the denser woods hold nails better than softer woods and are more difficult to nail and more liable to split, while the resistance to withdrawal within any one wood increases directly with the depth of penetration of the nail and almost directly with its diameter. The withdrawal resistance is also affected by moisture content in the wood after the nail is driven. The resistance to withdrawal of nails with circular plain shanks depends on the specific gravity of the wood, the nail diameter and depth of penetration.

K. S CHUNSI; **Hard wood lens key for Tanzania Timbers,** Technical Note No.? (1978)
The lens key contains descriptions of anatomical and other easily observed diagnostic features of some hard woods of commercial and botanical importance; the characteristics of the various timbers which are discernible using a hand lens are recorded in the marginally perforated cards. In order to identify the sample a pack of prepared cards is sorted according to features observed in the sample. The publication also gives the definitions, explanatory notes and end grain photomicrographs of the features used.

P. J WOOD; **Cypress studies Sawmill Recovery and Bark percentage,** Technical Note No 39 (1968).
In this study 22 yrs old *Cupressus lucitanica* were tested for bark percentage at various heights in the standing tree and in saw mill logs and later sown lumber recovery

percentage was calculated. The mean recovery for medium sized logs was found to be 54% and this is to be expected for well grown Cypress at the rotation age of 22 yrs old.
Wood properties and utilization of Acacia albida Series No. 2 1957
As compared to Podo it is 30% weaker in maximum bending strength properties, 25% less stiff and 40% weaker in compression. The tests were from Mapogoro.

K.S. CHUNSI; **Structural features of seventeen exotic and indigenous hardwoods of Tanzania–Wood Structure Series – 1978 No. 1.**
Identification of timber can be done either by the use of a hand lens or a microscope. General characteristics of a species such as appearance, colour, texture, weight, small are useful only up to a point in distinguishing different kinds of timber, but identification is simpler and more reliable if it is based on the characteristic structural features which remain unaltered under conditions which may entirely change the external appearance of the timber. Structural features of each species can be examined on the transverse surface, radial surface and tangential surface of a wood specimen using a hand lens which gives a magnification of 8 or 10 times. For more accurate identification however radial, tangential and transverse pieces of the wood are examined under the microscope which gives a much higher magnification. Seventeen hardwood species were examined under the microscope and the features are described in this report.

UTILISATION DIVISION; **The maintenance of Wide Band saws**
This note is published for the information of band mill operators in Tanganyika, and is intended as a rule-of-thumb guide for saw doctors who have only limited experience of band saw maintenance. Further information and direct instruction are available at the Utilisation division's saw doctoring section in Moshi.

UTILISATION DIVISION**; The Selection and Maintenance of Crosscut and Felling Saws (Logging Series No. 2)**
A considerable number of loggers in this Territory still fell by axe alone, and most of those that do use saws have only the simplest peg tooth type. It is obvious that in felling by axe a considerable wedge has to be cut from the butt long, and very often a foot or more of the best part of the tree is wasted. This extravagant practice continues because millers and fellers thin it easier and quicker and therefore cheaper. It is quite likely that axing is quicker than sawing with the type of crosscut saw in general use, but with the proper type of saw, correctly fitted for the particular timber, the sawyer can always beat the examine and save timber as well, and the resulting economy will more than repay the cost of efficient tools.

PART II

Peeling and gluing characteristics of various timber tree species

In this section we present abstracts of research done on peeling and gluing characteristics of different timber tree species.

K.S. CHUNSI & K.K CHINULA**; Peeling and gluing characteristics of *Chlorophora excelsa* and *Olea welwitschii***, Series No ? (1978)

The aim of this study was to assess the peeling characteristics of Mvule (*Milicia excelsa* sny. *Chlorophora excelsa*) and Loliondo (*Olea welwitschii*) and assess the quality of veneers thus produced for the manufacture of plywood. The strength properties of plywood were evaluated using the normal wood properties testing procedures.

K.S. CHUNSI & K.K CHINULA; **Use of black wattle Tannin Glue for Chipboard Manufacture in Tanzania**, Series No 3 (1978)
Experiment was carried out to compare urea formaldehyde and Black Wattle tannin glue in chipboard manufacture. The observations clearly indicated that black wattle tannin glue compared favourably well with Urea formaldehyde glue in the manufacture of chipboard provided the right formulation of the glue was used. Concluding from the very encouraging results from these trials it was recommended that small scale manufacture of chipboards using black wattle tannin glues could be by the chipboard manufacturing factories.

K.S. CHUNSI & K.K CHINULA; **Use of black wattle Tannin Glue for Chipboard Manufacture in Tanzania**, Series No 2 (1978)
The study was carried out to compare black wattle tannin glue and urea formaldehyde as bonding material in manufacture of chipboards from a range of tree species. There was strong evidence that there were no significant differences between the two materials in bonding suitability. The findings indicated that black wattle tannin glue compared favourably well with urea formaldehyde glue in the manufacture of chipboards.

K.S. CHUNSI; **Use of black wattle Tannin Glue for Plywood Manufacture in Tanzania**, Series No 3 (1978)
The experiment was undertaken to compare different formulations of black wattle tannin adhesive in manufacturing plywood from *Podocarpus* sp. (surface) and *Grevillea robusta* (core). The results indicated that about three formulations of black wattle tannin adhesive could be used to manufacture plywood from *Podocarpus spp* (surface) and *Grevillea robusta* (core) veneers. Also the black wattle tannin adhesive in Tanzania have lower cost than imported glue, natural and faster bonding at lower temperatures.

K.S. CHUNSI & K.K CHINULA; **Use of black wattle Tannin Glue for Plywood Manufacture in Tanzania**, Series No ? (1978)
The results from this study showed that the tannin extract formulation used was not suitable to be used as a bonding agent at least for the species used.

K.S. CHUNSI & K.K CHINULA; **Use of black wattle Tannin Glue for Plywood Manufacture in Tanzania**, Series No 5 (1979)
The aim of the study was to develop a highly reactive low cost type of adhesive based on the black wattle tannin extract for the plywood industry. Both fortified and unfortified glue

formulations which had been used in an earlier work were used in this project to assess their effectiveness in the bonding quality of plywood produced from *Cephalosphaera. usambarensis* instead of *Podocarpus* species (surface veneers) and *Grevillea robusta* (core veneers) which had proved successful. The results showed that all the four Black wattle tannin glue formulations were suitable for making *Cephalosphaera usambarensis* plywood provided the plywood is used under dry condition only. The plywood produced using the above formulation is suitable for making furniture and wall panelling.

K.S. CHUNSI & K.K CHINULA; **Peeling and gluing characteristics of *Fagaropsis angolensis*** Series No. ? (1979)
The results from this experiment showed that *F. angolensis* does not require long period of steam heating before it can be peeled satisfactorily; the species can be glued using urea formaldehyde glue satisfactorily. The plywood thus produced is suitable for use in areas not subjected to wet conditions.

K.S. CHUNSI & K.K CHINULA; **Peeling and gluing characteristics of *Ocotea usambarensis*** Series No. ? (1979)
The study showed that *O. usambarensis* peels satisfactorily after steaming for eight hours. The veneer produced makes good plywood.

K.S. CHUNSI & K.K CHINULA; **Peeling and gluing characteristics of *Rapanea phododendroides*** Series No. ? (1979)
The results from this study indicated that the species is suitable for use in plywood manufacture using urea formaldehyde as a bonding agent.

K.S. CHUNSI & K.K CHINULA; **Peeling and gluing characteristics of *Podocarpus milanjianus*** Series No. ? (1979)
The results obtained from this experiment showed that *P. milanjianus* is suitable for use in plywood manufacture using urea formaldehyde as a binding agent. The use of extender is recommended when bonding *Podocarpus milanjianus* though this reduces the strength of the bond slightly. The plywood produced can be used for furniture and panelling.

K.S. CHUNSI & K.K CHINULA; **Peeling and gluing characteristics of *Antiaris toxicaria*** Series No. ? (1979)
In this experiment, same test methods, applied for making plywood from *P. milanjianus* were used and the results showed that timber from *A. toxicaria* is suitable for plywood manufacture using urea formaldehyde provided the plywood is not used in areas that require high strength properties. It was also found that *A. toxicaria* was suitable as core material only in plywood manufacture.

K.S. CHUNSI & K.K CHINULA; **Peeling and gluing characteristics of *Cephalosphaera usambarensis*** Series No. ? (1979)
The results from this study indicated that the species is suitable for the manufacture of plywood with urea formaldehyde as a bonding agent. The manufactured plywood can be used for furniture making and general utility purposes.

K.S. CHUNSI & K.K CHINULA; **Peeling and gluing characteristics of *Podocarpus gracilior*** Series No. ? (1979)
After peeling this species could be successfully glued using urea formaldehyde to make plywood. The plywood produced from *P. gracilior* using urea formaldehyde is suitable for tea chests and general utility

K.S. CHUNSI & K.K CHINULA; **Peeling and gluing characteristics of *Casearia battiscombei*** Series No. ? (1979)
The species produced plywood suitable for both dry and wet conditions. It bonds better with urea formaldehyde. Plywood manufactured from this species was found to be good for tea chests, furniture and panelling.

K.S. CHUNSI & K.K CHINULA; **Peeling and gluing characteristics of *Cassipourea malosana*** Series No. ? (1979)
This study revealed that this species is suitable for manufacture of commercial grade plywood using urea formaldehyde as a bonding agent provided it is used in dry conditions only, like in making furniture and panelling.

PART III

Wood preservatives

Different wood preservatives have been tested by the Research Section of Forest Division and later by Moshi Timber Utilisation Research Centre since 1950s. Performance of different wood preservatives has been observed in the grave yards of Tanga, Moshi and Tabora for the past six decades. Research on the resistance of various timber tree species to preservatives impregnation were carried out in Tanzania until early 1980s and field trials of wood preservation were established in different sites in the country. Research findings are presented below.

P.F. NANGAWE; **Performance of wood preservatives in the grave yards of Moshi and Tanga** Tanzania, Progress Report (1959)
It reported that the main wood degradation agents were fungal affecting Tanga grave yard more while termite attack was the main cause of wood sample failure in Moshi grave yard. The study also found that over 16kg/m^3 Net Dehydrate Salt Retention (NDSR) of Celcure A is effective against termites and fungi at both sites of test. Creosote absorption was in excess of 180kg/m^3. Tanalith`c tests, only retention in excess of 16kg/m^3 NDRS were still surviving in Moshi. In Tanga, as low as 9kg/m^3 NDRS wood samples were still sound. Shell 58 seemed to perform well in both grave yards. Brunophen concentrate gave good protection in ground contact especially along the coast. Wykamol plus performed very well in both grave yards despite the simple dip treatment used; all the stakes showed fungal decay. It was concluded that wrapping with fabric material treated with Copper Naphthenate does not provide protection against fungi and termites.

UTILISATION SECTION; **The resistance to impregnation of *Cupressus lusitanica,*** Technical Note No 26 (1960)
This experiment revealed that, timber from *Cupressus lusitanica* is resistant, some time moderate resistant to impregnation with creosote, but it is treatable. The resistance varies widely between individual pieces; and the full cell process is recommended with the maximum pressure held for a period of 3 to 6 hours. As with some others softwood species, *C. lusitanica* is more easily impregnated with solutions of metallic salts in water than in creosote. Its rating with this is moderately resistant, and the full cell process is recommended with the maximum pressure held for periods up to one hour.

J.M BRYCE & H. NORCROSS; **The resistance of Tanganyika Timbers to impregnation** Technical Note No 28 (1961)
It was found that resistance to impregnation is governed by anatomical structure of the wood and can not be estimated from physical properties such as density. The standard method described by L.W. Redding in "The resistance of various timbers to impregnation was used to determine the penetration and retention of the creosote. Seventy five (75) species were tested and the results are presented. The penetration of preservatives varies between individual trees of the same species, with the position of samples within the tree. It may be uniform through out the cross section, greatest at the outside or at the centre.

J.M. BRYCE & H. NORCROSS; **Field trials of wood preservatives in Tanganyika,** Technical Note N0 30 (1963)
The paper describes the formulation and the result of wood preservatives tested by the Utilisation Section from 1955 to 1976.

J.M. BRYCE; **Diffusion Impregnation Experiments with Tanganyika Timbers,** Technical Note No 32 (1964)
One of the objectives of carrying out these tests was to attempt to device treating schedule for *Brachystegia* spp. sleepers. Treatment schedules were selected more or less arbitrarily for a preliminary series of diffusion tests on some of Tanganyika Timbers. Most of treatments were unsuccessful in obtaining adequate core loading or penetration or both, even where long immersion and storage times were employed. The partial success of some of momentary immersion treatments indicates the need for the use of solution concentration higher than 15% boric acid equivalent, and immersion periods probably well in excess in one hour. The results of the tests showed that minimum block-stacking times were needed for each species.

UTILISATION SECTION; **A Code of Practice for wood Preservation in Tanzania,** Technical Note No (1966)
This paper presents wood preservation schedules for timber species with different durability periods, preservatives and appropriate methods of application.

P. F. NANGAWE; **Wood Preservation in Tanzania,** Technical Note No ? (1970)

This study provides different types of wood preservatives, requirement for good preservatives and methods of treatment. It contains also the list of some of the preservatives which have been tested by the Utilisation Section of Forest Division.

P. F. NANGAWE; **Wood Preservation in Tanzania** Revised Technical Note (1976)
This is a revision of technical Note No ? of 1970 on the same subject with minor corrections in the list of some of preservatives which were tested by the Utilisation Section of Forest Division. In this note; wood preservatives, their properties, requirements for good preservatives and methods of treatments were studied.

P. F. NANGAWE; **Field trials of wood preservatives in Tanzania,** Technical Note No. 30 (Revised 1977)
In this technical note, the investigator presents a revised version of Technical Note No. 30 (1963). Descriptions of the preservatives, methods of application and retention levels are provided.

PART IV

Durability tests
In this section we present research done on timber natural durability tests in different sites for different timber species.

UTILISATION SECTION; **Natural Durability of Local Timbers**, Technical Note No 14 (1960)
Results of durability tests on the resistance of local timbers to attacks by subterranean termites and fungi for Tanga and Moshi graveyards are presented.

J. M. BRYCE & H.NORCROSS; **Natural Durability of Local Timbers**, Technical Note No 33 (1965)
Results are presented on observations of 76 timber species which were under ground contact for 10 years. Depending on their resistance to decay and termites in field conditions the timber species were classified into five grades namely; very durable (> 10 yrs), durable (5-10 yrs), moderately durable (2-5 yrs), non durable (1-2 yrs) and perishable (< 1yr).

UTILISATION SECTION; **Natural Durability of Local Timbers**, Technical Note No 14 (1969)
This paper is a revision of Technical Note No. 14 first issued in August 1962. The wood destructive agencies identified are termites, beetles, marine borers, fungi, mechanical wear, acids etc. Durability can be determined in the laboratory and in the field. In this paper two test sites were used, that is Tanga representing coastal conditions and Moshi representing inland conditions. From all sites termites were found to be the main timber deteriorating agents. All species tested were susceptible to fungal and termites attack in varying

degrees. Durability was graded into four grades depending on the time of existence in contact with the ground. These grades were; very durable (> 10 yrs), durable (5-10 yrs), moderately durable (2-5 yrs), non durable (1-2 yrs) and perishable (< 1yr).

P. F. NANGAWE; **Natural Durability of Local Timbers**, Technical Note No 14 (1976)
This Technical Note is highlighting on durability tests carried out for 19 years. It was by then concluded that since the natural durability tests were only for 19 years, the timber durability grades were not comparable with other laboratories.

P. F. NANGAWE; **Natural Durability Tests**, **Progress Report** (1979)
This progress report results of durability tests for forty one (41) timber tree species with a total of 831 stakes that were under test. Main causes of wood stakes failure were fungi and termites in Tanga and Moshi respectively.

K.K MURIRA; **Evaluation of Transmission Poles in Service Treated at the Timber Utilisation Commercial Section** (1985)
The study was carried out to examine transmission pole damage and data was collected at 20 cm above and 20 cm below the ground line. Examination comprised of a visual check of the pole surface and boring at the ground line to observe any degradation. The different agents of pole deterioration were identified namely fungi, subterranean termites, fire damage and checks. Similarly pole damage was classified into sound poles, incipient damage, moderate damage and severe damage. It has been recommended that proper procedures of handling and treating poles should be closely followed so as to avoid huge economic losses due to massive premature failures.

PART V

Timber seasoning and movement of timber

UTILISATION SECTION**; The weight and shrinkage of some local timbers** Technical Note No. 25 (1959)
In this study green and air-dry weights and percentage shrinkage from green to air dry weight of different indigenous species and exotics are presented.

UTILISATION SECTION**; The weight and shrinkage of some local timbers** Technical Note No. 8 (1959)
This paper presents different local timber tree species with their weight and shrinkage percentages at different conditions.

UTILISATION SECTION**; The air drying of local timbers** Technical Note No. 9 (1958)
The objectives of this study were to determine the time required to air dry local timbers with the thickness most commonly used; to determine the effect of factors such as climatic conditions and methods of stacking on the period required for drying and to determine the

degradation that occurs during drying, and methods of reducing it. Summary of results are presented in appendices. It was concluded that, since end splits, surface end checks and shake are measured at one end of the timber only, the totals for these defects must be doubled before averaging them to get the defect rate per piece of timber.

UTILISATION SECTION**; The kiln drying schedule of local timbers** Technical Note No. 3 (1960)
Determination of most suitable kiln drying schedules for local timbers to ascertain the amount of degrade that would occur in kiln drying and its effects on the grade and utilisation category of the timber was undertaken. Time required to kiln dry local timbers are also provided.

J. M. BRYCE; **Experiment with mechanical restraint in seasoning**, Technical Note No 24 (1961).
Pillar wood is very liable to twist in drying and the immediate effect of restraint was to reduce the twist to about half that of the control pile. Then it seems that pillar wood is too refractory to receive any benefit from mechanical restraint in seasoning.

J.M. BRYCE & G.A. KITAMBI**; The Air Drying Properties of Some Tanganyika Timbers,** Technical Note No 23 (1960)

The paper describes the results of air-drying experiments of 15 species carried out at Moshi Timber Utilisation Research Centre. The results of the tests are summarised for each species and the details are provided.

UTILISATION SECTION**; The kiln drying schedules for Tanzania timbers** Technical Note No. 38 (1966)
This study indicated that different timber species have widely different rates of drying and variable tendency to degrade. Thus in this paper various timber drying schedules are presented.

UTILISATION SECTION**; The movement of the local timbers** Technical Note No. 29 (1961)
Movement test on the number of local timbers have been made by the Forest Products Research Laboratory and Tanzania Utilisation Section. The results indicate that there are timbers with small, medium, and large movement values. In this paper it is indicated that the movement of the timber is caused by the change in moisture content by fluctuations in atmospheric humidity. Movement on the number of local timbers have been determined by Forest Products Research Laboratory (F. P. R. L), UK and the Tanzania Timber Utilisation Section of the Forest Division. F.P.R.L. and leaflet No. 47 Standard procedures for determining timber movement are described and the timber classification methods are given in F.P.R.L. Leaflet No 47 based on some of the percentage radial and tangential movements.

UTILISATION SECTION**; The movement of the timbers** Technical Note No. 29 (1966**)**
This is revision of Technical Note No 29 of 1961. Causes of timber movement are as stipulated in technical Note No. 29 of 1961. The only differences from that of 1961 are on percentages in tangential and radial movements at 90% and 60% Equilibrium Moisture Contents (E.M.C).

UTILISATION SECTION**; The weight and shrinkage of some local timbers** Technical Note No. 25 (Revised in February 1967)

The green and air dry weight and percentages of shrinkage from green to air dry of a number of indigenous species and plantation grown exotics are presented. Test procedures included determination of moisture content of each specimen from oven dried samples as soon as possible after sawing, and again at the end of the drying period when the weight of the specimen had remained constant for two weeks or more. The radial, tangential and longitudinal dimensions were measured with veneer callipers before and after drying.

PART VI

Energy research

B. T KIMARYO; **Use of coal for burning clay bricks**, (1979)
The study was carried out to test burning of clay bricks using coal as the main fuel at SIDO Mbeya. The results obtained have been compared to those from previous trial in Dar. One basic fact found in all these tests is that Tanzania coal is also suitable for burning clay bricks. An important less expensive kindling could as well be used such as dry maize stock, banana leaves, and rice husks for such a coal kiln.

B. T. KIMARYO*;* **The marketing of Charcoal in Arusha and Moshi districts** (1979)
The project aimed at knowing the quality and quantity of raw materials required to manufacture charcoal in the two districts. The results indicated high demand for charcoal by the town dwellers. Recommendations are made for further research.

K.S. CHUNSI & P.P CHINULA; **Species trials for match manufacture** (1978)
Total of 21 species were tried for suitability in the manufacturing of splints, inner and outer boxes. The summary are indicated in this paper but some of the species are *Bombax rhodognaphlon* its timber not suitable for large scale production of matches, *Calodendrum capense* its timber is suitable for making splints, *Cassipourea malosana* its timber not suitable for match making, *Cedrela mexicana* the timber not suitable for splints or boxes.

B. T. KIMARYO & K. I. NGEREZA; **Charcoal production in Tanzania using improved traditional earth kilns (1989)**
A preliminary field survey of earth kilns was carried in nine villages in Tanzania. Only one design of the traditional earth kiln was found commonly adopted in the surveyed villages. The effect of the basic design on charcoal yield and production cost was evaluated for comparison among villages. The charcoal recovery percentages from single kiln-charges in

the villages are unexpectedly quite high, ranging from 17 to 37 per cent. The yield variations between villages are significant due to lack of field control of certain factors of production: tree species, wood density, billet moisture content, kiln capacity, operating skills and prevailing weather conditions. The unit production costs showed no significant differences between village charges.
Experimental charcoal burning was then conducted at Kileo Forest Reserve, Mwanga District, to measure the technical and economical performances of five earth kiln models. The results showed quite significant variations in yields of charcoal between and within kiln designs. The recoveries between kiln designs ranged from 15 to 31 per cent. The unit production costs also differed quite significantly between the kilns designs tested, ranging from Tsh. 1 per kg (Tsh. 39 per bag) to Tsh. 3 per kg (Tsh. 108 per bag).
The results obtained at Kileo indicate that the Senegalese Casamance earth kiln is the most technically and economically efficient design, followed by the metal channel kiln, an improved version of the basic earth kiln. The adoption of either of these two designs by the rural charcoal producers may greatly improve the traditional method of charcoal production in the country

B. T. KIMARYO AND D. T. J. MASHITAKI October 1979; **Use of Coal for Burning Clay Bricks**

The burning of clay bricks consumers a lot of heat energy. At present firewood is the main fuel; although it is estimated that only about 0.2% of the total yearly cut goes to the brick burning industry. As the demand for firewood and charcoal is ever increasing in the household sector year by year, alternative sources of energy have to be considered. Coal is one of these possible alternatives.

Test-burnings of clay bricks using coal as the main fuel were conducted at SIDO, Mbeya, and the results obtained have been compared to those from previous trials in Dar Es Salaam. Four temporary field clamps with an average capacity of 1,400 bricks were build up one after another with varying modifications.

The main observations were:

- Coal is suitable for burning clay bricks
- Both temporary field clamps and permanent structures can adopt the fuel quite satisfactorily
- The consumption of coal ranged 0.76 – 0.95 kg/brick in field clamps while that in a permanent kiln was 0.73 kg/brick.
- The recovery from field clamps was between 33 and 35% compared to 75% from a permanent kiln.
- The cost of production was between Shs. 0/78 and 1/33 per brick for field clamps are compared to Shs. 0/35 per brick for a permanent kiln.
- The field clamp needs yet a more modified version before adoption by small-scale producers in the villages.

PART VII

Forest protection

A. K. RWAMPUTA; **The effect of pine woolly aphids (*Pineus pini*) on quantity of *Pinus patula*** (1987)
The study conducted on *P. patula* of 7yrs and the results obtained in this study showed a negative correlation between aphid density and cumulative volume of *P. patula* was observed. The pest was also found to cause cumulative volume reduction of 82%. Severe damage began occurring at a density of about 0.88 aphids per cm. Then the biological control systems using natural enemies were recommended for the control of the pest.

PART VII
Non-Timber Forest Products
Forests provide non-timber forest products which are often neglected in the forest products trade records. The extent of harvest and contribution of these products to the rural economy is not understood. Large amounts of indigenous tree medicines, aromatic plants like sandalwood, orchids, gums, resins, oilseed, fruits etc. are harvested from the forests and form important part of community socio-economic activities. The harvesting of these products can also be detrimental to the genetic resource and environment as others involve debarking and uprooting of whole plants. Below are some studies carried by the Moshi Timber Utilisation Research Centre on NTFPs.

B.T. KIMARYO; **Medicinal plants surveys in Tanzania** (1984)
The medicinal plants Dodoma and Lindi regions were studied using questionnaire surveys and the results are presented. Plant species with different medicinal values were identified into botanical and common names, medicinal portions of the plant, medicinal values and how to prepare the concoctions.