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POSSIBLE USES OF TROPICAL WOODS AND THEIR DERIVATIVES FOR BUILDING PURPOSES IN DEVELOPING COUNTRIES[1]

by

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1/ The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the secretariat of UNIDO.

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INTRODUCTION

1. Among developing countries, certain have very little or even no exploitable forest, and it is not surprising that wood is very little used in construction work in such places. However, despite the severe climatic conditions obtaining in these countries, certain tropical woods could be used there as successfully as other materials imported at high prices.

On the other hand, there are many countries covered with huge, thick forests which sometimes account for more than half the total area of the territory. Most of them produce and export timber, and have sound reputations on the world tropical-wood market. This is true of the forest countries of South East Asia, which are the largest suppliers of tropical broad-leaved timber.

2. From the earliest times, wood has been used in housing construction, and its use has now reached a high degree of evolution. Wooden houses fall roughly into two categories: the Chinese type, with a ground floor, and the Malay or Thai house built on stilts. The latter is very logical, as the wood is isolated from the ground to prevent termite damage. Woods susceptible to damage from insect pests of any wood are not used. The eaves are very wide to protect the walls from bad weather (risk of rotting) and from the sun (in order to keep the house cool). Often the houses have some aesthetic pretensions, and are very pleasant to live in. Many of them are over a century old.

Examples of the wooden house are also to be found in South America. Paramaribo, the capital of Surinam, is almost entirely composed of one or two-storey wooden buildings in a very striking style, with wide overhangs to protect the balconies against rain and sunshine.

In Africa, also, at least in the densely-forested countries of tropical and central Africa, wood has always been used in traditional buildings in the form of poles for making the framework of simple huts. These still form a considerable proportion of the dwellings, providing shelter, even today, for 60 to 80 per cent of the population in these areas. The walls are generally made of wooden frames filled with earth or covered with bark. Less frequently, they are made of planks obtained by splitting soft woods, like the "carabotes" at Ilomba in Cameroun.

In this type of house, wood is also used for fencing and for making shelters for domestic animals. When possible, a few planks, recovered from packing-cases, are used to make doors or solid shutters, the main use of which is to prevent burglary. At this level of housing, wood is little used for the decoration of the houses, the floors of which are usually made of beaten earth and which have no ceilings and few dividing-walls.

Although this type of dwelling is indeed associated with a subsistence economy in which households can only afford to buy manufactured goods essential to their daily lives, it is still surprising that wood occupies such a relatively modest role in modern buildings in the towns.

3. Naturally, wood is used in modern buildings, especially in the form of framing for the concrete-work and very often for windows, doors and timber-work, and even sometimes for floors and staircases. But it is often replaced by other materials: metal for the windows and ironwork in place of timber-work, plastics for floor-coverings, concrete for staircases, etc. Completely wooden constructions, prefabricated in factories or built up on the site after the parts have been cut up in workshops, are still infrequent, and are mainly reserved for administrative offices or school buildings. Recent experiments, however, especially in Gabon, have shown that wood used in the form of facade panels can very well be incorporated in a concrete structure, adding to the comfort and appearance of the building. It is hoped that these initiatives will be pursued in the future.

On the other hand, in the field of industrial buildings, and despite fine examples which contractors usually do not know about, wood is practically absent, and its place is taken by iron and reinforced concrete, despite the fact that wood can be successfully used, not only for small sheds, but also for large buildings in which the technique of glued laminated wood permits achievements that would be impossible with other materials.

In the light of what has already been accomplished, it can be stated that, within a market economy, wood can play an important role in construction work.

4. In the course of the following paper we shall first examine, in Part One, the technical characteristics of tropical woods and their derivatives, a knowledge of which is essential for their correct use in building and for an increase of that use.

Part Two deals with the availability and prices of tropical woods and derivatives for building purposes in West and Central Africa.

Part Three discusses the main problems to be solved and the action needed for developing the use of tropical woods and materials for building purposes in most of the developing countries.

I. TECHNICAL CHARACTERISTICS OF TROPICAL WOODS AND THEIR DERIVATIVES WHICH CAN BE USED FOR BUILDING PURPOSES

1.1. Solid wood

1.1.1. Physical and mechanical characteristics

Before a wood is used for any purpose, we must know its properties. For European woods, this knowledge is empirical and stems from tradition. The same cannot be the case, however, for most tropical woods in countries where their use on a large scale has developed only recently. Their wide variety and their differences from woods of temperate countries (poorly visible growth rings, tangled grain) are disconcerting to the expert. The only way to discover their characteristics is to subject them to laboratory tests.

These tests have been devised in order to examine the characteristics on which most uses of wood as a building material depend. Some of them concern physical properties, which often play an important part in the choice of a wood (weight, hardness, shrinkage). Others concern the mechanical strengths needed for judging the quality of the wood with respect to stresses corresponding to various uses (bending, compression, tension, shearing). This knowledge is not only essential for large timber-work constructions, but also for wood used in joinery and furniture manufacture, where certain elements are sometimes subject to considerable stress.

Among the characteristics of wood, the physical ones are the most easily discovered and the best-known, and are therefore the first to be taken into consideration.

The first of these properties is density. Whereas the specific gravity is the weight of a unit of volume, the density is the ratio between the weight of a certain volume of a body and the weight of the same volume of water. In the metric system, these two values are the same, and they are often confused with each other. However, as wood is a hygroscopic substance, the figures for these properties depend upon the amount of water it contains, and standards of various countries lay down at what rate of humidity these values are to be calculated (in France the rate is 15 per cent). The importance of density lies in the correlations which exist between it and many other properties of the wood: though not constant, these correlations often allow a summary notion of the value of a given timber to be gained.

Hardness is another characteristic which is fairly easily detected. It is easy to distinguish between soft woods, such as the silk-cotton tree, which can be dug into with the fingernail, woods of average hardness which can easily be marked with any hard object, and the very hard woods which one cannot even scratch. Hardness is difficult to measure objectively, and methods vary from one country to another, but its study enables one to make a classification of timbers, and, by comparing them with other well-known woods, to determine their possible uses (for example, woods used for wood block flooring should have a hardness greater than 3 in the French scale). In general, hardness correlates with density, as these two factors vary in the same direction.

The humidity-absorption index of wood is doubtless its most important physical characteristic. All wood contains water, but the amount it can contain varies. One must, therefore, be able to discover the quantity of water in a type of wood at a given moment - i.e. its humidity, or water content - and study its variation. Standing timber or trees that have just been felled always contain large amounts of water. On exposure to air, the logs lose water until such time as there is a balance with external conditions of temperature and humidity. Thus the amount of water present in a piece of wood will vary with external conditions. As the chief properties of timber vary with its humidity, it must be stated under what conditions they were measured, the French standard being 15 per cent of humidity. Finally, the study of humidity variations in wood has brought to light a special value, known as the "fibre saturation point". In very damp wood, water is present in two forms; one part is free water, which fills the various pores of the wood, while the other part is imbibed water, which is incorporated in the cellulose walls of the wood-cells. As drying takes place, the free water is the first to disappear, and this first phase involves no change in the wood's properties. The fibre saturation point is the humidity value at which wood contains the maximum amount of imbibed water, but no free water at all. Below this point, any change in humidity will lead to variations in the properties of the wood.

Shrinkage is the underlying physical cause of the gravest faults of which wood stands accused. Below saturation-point, the volume of the wood decreased in proportion as the humidity drops, and increases again as it rises. This leads to a greater or less degree of warping, which leads to trouble in the use of wood. Shrinkage is expressed by a number of values: total volumetric shrinkage, which gives the variation in the volume of a piece of wood as a function of humidity changes; the coefficient of volumetric shrinkage, which measures changes in volume for a 1 per cent variation in humidity; and linear and tangential shrinkage, which indicate changes of dimension in these two directions. Thanks to knowledge of these data we can predict how wood will behave when its humidity changes as a result of drying or of seasonal climatic variations.

The mechanical characteristics have been studied to find out how wood behaves under conditions of its use. There are two groups of these, depending on the texture of the material itself:

- axial cohesion characteristics, which concern stresses in the direction of the wood-grain:

  Axial compression
  Static bending
  Dynamic bending

- transverse cohesion characteristics, which concern stresses perpendicular to the wood-grain:

  Splitting
  Perpendicular tensile strength of grain
  Longitudinal shear.

For each of these characteristics, tests enable the unit strengths to be determined. These naturally vary not only from one species to another, but also from one sample of the same species to another. It has been noted, summarily perhaps, that in all cases these variations fit in with variations of density, and it was concluded that these unit strengths could be linked to the density. Woods which have a high strength/density figure, for a given strength, are the lightest woods to use. The notion of weight is very important in building.

Mechanical characteristics not only enable us to judge wood, but also to give strength calculation formulae for calculating the maximum permissible stresses for the various parts of a building. If these formulae are to be valid, one must have done enough tests to be able to give a reliable average. It is also essential to distinguish between species: some are very homogeneous, and the figures given are valid; others are not, and the figures for them are worthless. To correct these errors, large safety coefficients must be introduced into the calculations of admissible stresses, as well as correction coefficients to take account of any errors.

Values for mechanical characteristics are always given for wood at a given humidity, generally 12 per cent (Geneva Conference of 1949). Coefficients are calculated for each value so that the values for admissible stresses can be corrected in the light of the humidity of the wood at the time of its use.

The grain compression test measures the breaking-stress of end-loaded pieces (poles). The test is carried out on specimens of faultless wood and of short length, in order to exclude buckling. The figure given for the admissible stress is one quarter of the arithmetic mean of the breaking-stresses. Moreover, in order to provide for faults (knots, split grain), the figure is mulitiplied by a coefficient varying from 0.9 to 0.5, depending on the importance of the faults.

Static bending-tests provide breaking-stress figures for faultless specimens, supported at both ends, to which progressively heavy weights are applied at the middle. However, the values thus obtained are difficult to apply for calculating admissible stresses, and other methods are preferred. Two are usually used in France, one of which is based on the admissible compression-stress. In any event, the test is mainly comparative, the characteristics enabling a comparison of woods to be made, thus showing which species are most suitable for bending.

Dynamic bending or resilience tests show the resistance of specimens to dynamic bending. The work required to break a specimen of standard dimensions is measured. This is a rapid test, showing which woods stand up well to shocks, and also revealing latent faults in specimens, and is an excellent reception test.

Tests to measure transverse cohesion, splitting, perpendicular-to-grain traction and shearing properties are very important in building, because the solidity of assemblies will depend on the wood's resistance to these efforts. However, the values found are very hard to interpret, and they depend very much on the form of the specimen. For example, the breaking-stresses for the same wood are higher with standard US specimens than with French ones. The tests are thus essentially comparative, enabling a classification of woods to be made.

This description of physical and mechanical characteristics shows how a fairly rapid knowledge of the quality of a given wood can be obtained through laboratory tests. For certain properties, this knowledge remains vague, because it is essentially based on comparison with the better-known species, but even this is useful, because it leads to the elimination of woods inferior to those normally used for building purposes.

In certain cases, the tests enable the conditions of use to be defined with precision. Studies of humidity and shrinkage show how to carry out correct drying and avoid deformations once the wood is used for building. The specific gravity shows the exact weight of the assemblies, which it is necessary to know when laying the foundations of the house, and through the admissible stresses we can calculate the various elements of the assemblies which are under stress.

However, the extrapolation of the results obtained on small specimens to large pieces of wood (planks, beams, squared timber) is always difficult, and must be undertaken with care, taking account of faults, the density and humidity of the wood, and the botanical species. It would therefor be very interesting to have tables giving data that can be used directly. In order to do this, it would be necessary to study the influence of various faults on the strength of wood. A number of categories, which would take into account the loss of strength caused by these faults, could thus be defined. There could be several types of tables.

It would be interesting to have a table showing, for a given species or group of species with very similar characteristics, the admissible stresses according to type of use in accordance with the above categories.

We could also try to lay down for a given use (beams, for instance) the minimum section of the pieces to be used according to the weight they had to bear, species by species, classified by categories according to their faults.

It is certain that if users - architects, builders and manufacturers - had such information, their work would be made easier. They could much more easily calculate frameworks, joisting, pieces of joinery, fixtures and assemblies, and this would encourage them to use wood as a building material, thus contributing to the development of the timber industry.

1.1.2. Drying characteristics

Studies of water-content have shown that wood always tends to be in balance with the temperature and humidity that surround it. For most types of use, wood has to be dried in order to bring its water-content down to the level needed for average conditions of use.

Drying is a complex affair. Its obvious purpose is to lessen the water-content of the wood, but, in doing so, it causes a number of changes both in the material and its characteristics. In the course of this paper, we have mentioned the influence of the water-content of wood on all its characteristics. The study of shrinkage has shown the variations of dimensions and volume which take place as humidity varies. The volume and dimensions of the wood diminish as it dries. If these variations take place once the wood is in position, they will cause the troubles so well known to wood workers: joints that open, assemblies that disintegrate, warping of parts that causes weakness or makes the piece useless (as in the case of windows, for instance). Therefore, in order to avoid these drawbacks, the wood must be machined and assembled only after it has been stabilized at the average climatic conditions of its use; that is to say that after humidity has been balanced with those conditions.

For this purpose, the wood must be dried. This can be done in the open air, and this method is recommended in tropical climates, where the constant high temperatures enable rapid drying. However, the balanced humidity remains fairly high (18-20 per cent at Abidjan, Douala and Libreville), and this may be a cause of trouble if the wood is used in an air-conditioned building or exported to drier areas such as Senegal or Chad. Wood may be artificially dried, but this is more difficult, because wood subjected fairly rapidly to high temperatures may warp and split. To avoid this, knowledge of the best drying techniques is required. Account must also be taken of the texture of the species and the way the wood has been sawn: tangled grain, cross-cut, oblique grains or against-the-grain.

1.1.3. Machining characteristics

Tropical species cover a very wide range of woods, and the conditions in which they are worked depend mainly on their hardness and their silica-content.

In general, the equipment used for machining tropical timbers is bigger and more poweful than that required for timber from temperate zones. If the wood is rich in silica, tools made of special steel or having teeth covered with an alloy that has high resistance to abrasion are needed.

For sawing the wood, large and sturdy equipment is needed on account of the weight and size of the logs. Hard and very hard woods oppose great resistance to the penetration of the saw-teeth, and therefore thicker blades must be used, necessitating the use of band-saws with large-diameter wheels and powerful motors.

Silica-rich woods rapidly blunt the saw-teeth, but this can be overcome by covering the points of the teeth with a very resistant alloy such as stellite. The increase in the life of blades treated in this way varies with working conditions, but it is rarely less than five times and often over ten times the normal life.

Most tropical woods can be planed, shaped and turned without much difficulty. However, the hard and very hard woods require two to three times as much power in planing as woods from temperate zones. Cross-grain is a frequent drawback of tropical timbers, and it causes problems with ordinary planes. This difficulty can be obviated by using planes with an angle of slope of 10 to 15°, but this reduction of slope is not always easy, and calls, in the case of large outputs, for special high-powered machinery.

The presence of silica causes less trouble in planing than in sawing. In shaping, it is nevertheless advisable to use tools with chromed or tungsten carbide surfaces.

Drilling and mortising with good steel tools do not present difficulties with most tropical woods.

In general, sanding raises no problems. Tropical hardwoods take a fine polish. The dust of certain woods (Pete and Makore, for example) has an irritant effect on the skin and mucous membranes, but this risk can be avoided by efficient aspiration of sawdust and shavings.

1.1.4. Durability characteristics

The durability of a timber is a specific property which is as important as its physical or mechanical ones. It characterizes the resistance of the wood to attacks by fungi and insects. Some woods are resistant in themselves, but others are subject to attack by these pests when certain biological conditions occur.

We must thus know the natural durability of woods in order to choose species suitable for specific building purposes.

Even in wood subject to attack, fungi can only develop if humidity is high - higher, that is, in most cases than the humidity equilibrium level between the wood and its surroundings. One way of avoiding fungus damage is to use only wood that has been perfectly dried and use it in conditions which will protect it from becoming humid again. Similarly, nearly all species of termites need sufficient supplies of water, which they can find in the wood itself or in the soil if conditions of use are defective.

On the other hand, "dry wood" insect pests need less water and will attack certain timbers independently of the conditions in which the latter are used. Among these pests are termites of the genus Cryptotermae, the bostrychids and the lyctids. Both bostrychids and lyctids limit their attacks on wood to those species which contain starch, a substance required for their diet. The simple fact that a wood contains no starch means that it is safe from attack by these insects.

In all species in which the sapwood and the heart wood are clearly differentiated, only the sapwood contains starch. Thus, in order to have insect-resistant wood, it is merely necessary to remove the sapwood. In cases where the sapwood and the heart wood are almost indistinguishable, however, starch may be distributed throughout the wood, which may thus be subject to massive attack.

When the wood is likely to be used in conditions where its natural durability is insufficient, it must be improved by treatment, and this should begin at the time of felling, as attacks by insects and fungi can begin at once and cause serious damage, even to the extent of making the wood useless. Similar treatment should be applied to sawn wood in order to ensure preservation before use, especially during drying.

However, in the case of most species, such treatments for logs and sawn timber are only effective superficially and temporarily, and do not give lasting protection. This can be ensured by treatment adapted to the use for which the wood is intended, after it has been machined but before it has been assembled.

There are several types of wood treatment. Pressure impregnation in an autoclave ensures the best penetration of antiseptic products. Soaking or painting are easier procedures, and although impregnation is less thorough, protection thus afforded is sufficient when the wood is not to be used in very unfavourable conditions.

These considerations show the importance of laboratory studies, which alone can enable us:

- To judge the natural durability of timbers by subjecting them to the attacks of biological agents likely to be harmful to wood used for building purposes.
- To discover the most efficient preservation techniques in the light of the species and intended use of the timber, and thus to indicate the type of treatment and preserving product to be used.

1.1.5. Characteristics of wood affecting its assembly

These concern all operations entering into the assembly of machined pieces for building purposes.

The usual methods of assembly are by means of nails, screws and glue.

It is possible, knowing the physical and mechanical characteristics of the wood, to forecast any difficulties which may be encountered in using nails. Very hard woods are difficult to nail, and cleavable ones tend to split. It is also useful to determine the resistance to removal of nails, for upon this will depend the solidity of the assembly. This resistance varies from one species to another and can only be determined by special tests.

Assemblies held together by screws are much used in building, and all iron fittings are fixed in this way. Hardness of the wood will also have an effect on the hold of the screws, but the texture of the timber also plays a part. This holding capacity should also be determined by special tests.

Finally, wood can be glued in many different ways. The glue to be used varies according to whether the assembly is to remain outside the building and thus be exposed to damp, or inside, sheltered from bad weather. There may be some difficulty in glueing tropical woods because of their chemical composition. The right type of glue for each use must be studied, and the glueing difficulties and means of overcoming them must be determined for each species.

Wood finishes are intended to protect the wood once the piece of work is in place. Whatever type of finish may be chosen, it cannot be correctly applied unless the wood has a humidity of less than 20 per cent at the moment of application.

Painting is the simplest method, and can be applied easily in most cases. It affords good protection and is lasting. However, there are certain species, such as Iroko, which require the use of special paints.

Varnish is very often used. This method is attractive to the eye on fine-coloured woods, but it deteriorates rapidly. In addition, the colour of the wood changes with age, because most varnishes do not act as a screen for ultra-violet rays.

New coloured finishes have been perfected which, apart from their decorative effect, have certain preservative qualities. They are simple to apply, and last longer in the case of woods which are easily impregnated. Experience of their use in insufficient to permit of any judgement of their worth.

1.2. Technical characteristics of wood board

For a long time, wood was only used in a solid state. This form of use is still the most important, and almost the only one in underdeveloped tropical countries. However, there are products made from wood which enable some of the faults and difficulties of solid wood to be overcome. These products are:

- **Plywood**, which is made of several layers of wood glued together (hence the name of laminated board which is also used).

- Fibreboard, made of agglomerated wood-fibre.

- Particle board, in which the wood has already undergone some processing.

These products are already known even in countries which do not produce them, as they are imported in small quantities. Their use develops when producing industries are installed and they become more readily available. This has already proved true for plywood, and is beginning to come about in the case of particle board.

1.2.1. Physical and mechanical characteristics of plywood, fibreboard and particle board

Plywood consists of an odd number of sheets of wood (veneers), of varying but always slight thickness (from a few tenths of a millimetre to several millimetres) glued together with the grain of one sheet perpendicular to that of the next sheet. These sheets retain the structure of wood, and plywood thus has the characteristics of the wood from which it is made, modified by its manner of assembly. The properties of plywood depend:

- On the quality of the veneers used.

- On the number and thickness of the sheets.

- On thr quality of the glueing.

One of the main reasons why plywood is preferred to solid wood is its horizontal dimensional stability to humidity variations. In the direction of its thickness, plywood behaves like a plank of solid wood.

Plywood is classified according to the quality of the glue and the outer veneers used. The glue may be water resistant if need be, or not resistant to water for uses indoors.

When the plywood has to undergo stresses in use, tests for admissible stresses should be applied to it, as in the case of solid wood. These stresses vary considerably, depending on the species of wood from which the plywood is made. Reduction factors are applied to take account of the length of time loads will last, the maximum faults present, and the general behaviour of the board as revealed by experience acquired in various countries.

For instance, the stresses generally agreed to in France for Okoumé and Mahogany plywoods are:

Species	Tension	Compression (in kg/cm²)	Bending	Shear	Modulus of elasticity
Okoumé	100	50	60	25	4×10^4
Mahogany	130	65	90	30	5×10^4

Fibreboard, unlike plywood, has a texture very different from that of solid wood. It is made from fibre, which is wood in a very broken down form. The fibre is spread out as a "mat" and is subjected to pressure at high temperatures. This gives various types of board, generally classified as hardboard, medium-density board and insulation board.

The main properties of these boards are summed up in the following table:

	Standard hardboard	Medium-density board	Insulation board
Density	0.90 - 1.05	0.42 - 0.80	0.25 - 0.40
Bending breakage modulus, kg/cm²	300 - 550	105 - 280	15 - 55
Bending elasticity modulus, kg/cm²	30 to 56,000	14 - 49,000	1,700 - 8,800
Tensile strength parallel to surfaces, kg/cm²	210 - 400	85 - 210	15 - 35
Tensile strength perpendicular to surfaces, kg/cm²	3.5 - 6	2 - 6	0.7 - 1.7
Absorption of water by immersion for 24 h at 20°C (% of weight)	10 - 30	6 - 40	15 - 60
Maximum linear swelling, %	0.60	0.2 - 0.4	0.50
Coefficient of thermal conductivity Kcal/h/m²/°C/m.	0.13	0.06 - 0.10	0.035 - 0.056

Fibreboard is much more prone to creep than plywood, and cannot in practice be used to support permanent loads.

Particle board is made of wood fragments mixed with glue and agglomerated under varying pressures. There is a wide range of them, from insulating board to hardboard. Each type of panel has its particular use in the building trade.

The average values for the main physical and mechanical properties of these boards are given in the following table:

Properties	Insulating board	Medium-density board	Hardboard
Density	0.30 - 0.40	0.40 - 0.80	0.80 - 1.05
Breakage modulus (kg/cm^2)	30 - 75	100 - 500	200 - 530
Elasticity modulus (kg/cm^2)	7 - 14,000	10 - 50,000	28 - 70,000
Tensile strength perpendicular to surface (kg/cm^2)	1 - 2	[illegible] - 12	20 - 30
Linear swelling, %	0.15 - 0.20	0.2 - 0.6	0.35
Coefficient of thermal conductivity ($Kcal/h/m^2/^{\circ}C/m$)	0.050 - 0.060	0.05 - 0.12	-
Absorption of water by immersion for 24h at 20°C, % of weight	20 - 75	1[illegible] - 40	

1.2.2. <u>Machining characteristics</u>

The maching operations for all types of board are generally the same as for solid wood, but the machining technique is different and some difficulties may be encountered as a result of the glues used in manufacture and the density of the various types of board. The glue often makes the material very abrasive, and the density means that their hardness varies considerably.

However, these problems are not an obstacle to the use of board, and the solutions to them are well known. To counter abrasiveness, tools made of special steel are used, or the cutting edges are covered with alloys resistant to abrasion. Powerful motors are also useful when machining board.

In the case of particle board, the edges are relatively fragile, and certain precautions must be taken when assembling this material.

1.2.3. Durability characteristics

If the right glue has been used and antiseptic products incorporated, board of the desired durability is obtained. It is possible to make board which stands up very well to humid conditions, which is a great advantage over certain solid woods. So far, only plywood has been used in humid surroundings, but efforts are being made to introduce particle board for exterior use. Some commercially-produced board meets these special uses; so far, however, its price has been a limiting factor.

1.2.4. Characteristics of use

The characteristics described above show that board derived from wood is very different in structure and properties from wood itself. These differences are often improvements, and open up many new uses for board.

The simple fact that these boards have a surface far greater than that of any plank gives them an important role in modern applications of wood. Certain elements of a building can be more satisfactorily made with boards than with planks, and such boards' lower cost of installation makes them competitive with solid wood.

Board presents no special difficulties for nailing and screwing, although particle board has a lower resistance than other types to the pulling-out of screws, a fact to be taken into account when designing assemblies.

Glueing, painting and varnishing are no more difficult than in the case of solid wood. Often the boards are covered during manufacture with paint or resin and then oven-dried, thus ensuring a perfect finish and making the work of installation easier.

The edges are the weak points of board, as it is here that damp can enter. In the case of thin board, protection is afforded by painting or varnishing; thicker boards can be framed with solid wood or have veneer strips glued over the edges.

The choice of the type of board to be used should be based on the following principles:

<u>Plywood</u>: Plywood made of broad-leaved tropical timber is intended primarily for decoration or for uses where it will undergo stress. For such decorative uses as cabinet-making or wainscoting, the most beautiful grain and freedom from all faults must be sought at all costs. For packing cases or rural uses, however, the price must be as low as possible.

For boat-building or use as exterior panelling, the plywood must be made with glue that is highly water-resistant.

<u>Fibreboard</u>: In building, hard fibreboard can be used for exterior panelling, the lower layers of floor-covering, wainscoting, flat door-surfaces and shuttering for concrete-work. Insulation board is used on dividing walls and for interior finish because of its heat- and noise- insulating properties.

<u>Particle board</u>: This is much used in building, especially for dividing walls, cupboards and built-in furniture. It can also be used, when restoring old buildings, for covering inside walls and ceilings.

II. AVAILABILITY AND COST OF TROPICAL WOODS AND THEIR DERIVATIVES WHICH CAN BE USED FOR BUILDING PURPOSES

2.1. Availability

2.1.1. Species traded in

Most tropical countries, many of which are developing countries, have enormous forests with exploitable areas of hundreds of millions of hectares. These forests are very heterogeneous, and it is generally considered that altogether they contain several thousand different species of trees.

However, only a few of these species are exploited, and less than a hundred of the tropical African species are used at present, while only some twenty of these are traded in on a substantial scale.

A feature of tropical forest exploitation seems to be that each producer country specializes in the production of a very limited number of species, which are not always the predominant species of the forest, but rather those most sought after on the export market and therefore the most valuable. It sometimes happens that a particular country has a predominant species which is also sought-after. This is true of the Ivory Coast, which is the main producer of Sipo, a very expensive wood in great demand, and Samba, which grows abundantly and for which there is a wide market. A fact which must not be forgotten is that no species is normally exploited for local use alone, and in African countries the only woods used locally are those which could be exported.

A list is given below of the species available in seven tropical countries of French-speaking Africa. Some, like Cameroun, have large forests and are timber producers; others, like Senegal, have no forests and either import logs from neighbouring countries or sawn wood from them or even from temperate countries. The species are grouped in three categories:

1. Those used most of the time;

2. Those used relatively often;

3. Those sometimes used to replace 1 or 2.

Type of use	Frequency of use	Cameroun	Ivory Coast	Congo Brazza	Gabon	Central Africa Republic	Sénégal	Tchad
Shuttering for concrete work	1	Samba	Samba	Limba	Okoumé	Samba	Samba	Samba
	2	Eyong	–	Samba	Ozigo	–	Kapok tree	–
	3	Fraké	–	–	Olon	–	Umbrella pine	–
Framework	1	Iroko Mahogany	Tiama Sipo	Limba Bilinga	Okoumé	Sapele	Iroko	Sapele
	2	Bilinga	Framiré	Niové	Douka	[illegible]	Framiré	–
	3	Movingui Azobé	Iroko Douka	Mahogany	Bilinga Iroko	–	Dibétou Sipo	–
Joinery	1	Sapele	Sipo	Mahogany	Okoumé	Sapele	Sipo	Sipo
	2	Landa Mahogany	Mahogany Niangon Sapele	Bilinga Moabi Douka	Douka Moabi Niangon	Sipo	Sapele Iroko	Sapele
	3	Bossé Tiboto Movingui Doussié	Framiré Tiama Iroko Douka Lingué Bossé Bété Dibétou Avodiré	Iroko Izombé Agba Kenzi Doussié	Izombé Movingui Ozigo Bilinga Iroko Sipo Dibétou	Doussié Samba Iroko	Lingué Framiré	–

This list shows that only about ten species are commonly used in large quantities for building purposes in French-speaking Africa. However, it also appears that at least 40 species, which are sometimes very abundant in the forests, are traded in to different extents in various countries. Apart from these main species, there is a fair number of others which are almost never used, although studies by timber research centres have shown that they could be. A few examples are:

- For light framework: Frake and Eyong, which are easily worked and abundant in the forests, but require preservative treatment;
- For heavy framework: Congotali, Mukulungu and Azobe;
- For exterior joinery: Bete, Bosse, Bilinga, Framire, Moabi and Tiama;
- For interior joinery: Avodire, Agba, Diletom and Tchitola;
- For work requiring great natural durability: Azobe, Lingue, Tali, Congotali, Padouk and Mukulungu;
- For decorative work: Izombe, Movingui, Bubinga and Kenzi.

Thus, it can be seen that African countries have a wide range of tree-species which can be used for building, although only a very small number have been used so far. The same is probably true for many tropical countries in other parts of the world.

2.1.2. Available products

Although most of the timber produced in tropical countries is exported in the form of logs, that is to say without having undergone any industrial processing, forest countries often have more or less developed wood industries, which use second-quality logs to make good-quality products for export. The unexportable inferior-quality production of these factories is sold locally.

Sawmilling and wood-based products

Most of the industries in this field are fairly small but diversified, engaging in the production of sawn wood, framework construction, crate-making, joinery, cabinet-making and even coach-building. The same is true at the artisan level, carpentry, joinery and furniture production often being carried on in the same workshop. There are usually no firms specializing in making wooden houses or parts of houses, although all woodwork needed for building purposes can be found on local markets.

Plywood and veneers

The making of veneer, nearly all of which is obtained by peeling, and of plywood is only carried on in a few factories so far, although some of them are among the largest in the world (the SOCGI in Gabon, for instance). The large ones concern themselves with the export market, while the smaller ones try to satisfy local or regional needs.

Fibre and particle board

Few developing tropical countries have fibreboard factories. There are very few particle-board factories (there is only one in the whole of French-speaking Africa). The board produced is used in furniture and building.

2.1.3. **Conditions of supply**

Problems of timber supply vary greatly according to whether the country is forested or not. In forested areas, the supply of logs for sawing, peeling or plywood manufacture is very easy. The factories often possess their own forests, which provide at least part of their needs. As these areas export logs, the sawmills in the ports can easily buy timber of a non-exportable quality at low prices.

Supply for sawmills outside forest areas or in forest exhausted by exploitation is another matter. There are, for instance, several sawmills in the interior of the Ivory Coast, in formerly-exploited areas, which have difficulties in accumulating a stock of logs at certain times of the year. In Senegal, sawmills depend upon the import of logs of adequate quality at a low enough price to produce sawn wood competitive with imported wood.

Supplies of sawn wood, plywood and veneers for industries which use them often cause problems, but these are different from those affecting the supply of logs. On local markets, only medium-quality plywood and veneers are usually available. In addition, the number of species used locally for making veneers and plywood faces is very small, and most of the sliced veneers and plywood made from decorative tropical timber are, paradoxically, imported.

As for sawn wood, only small stocks are held on local markets. Orders are usually only carried out on request, and may take from a few days to a month or more. The sawn wood is usually delivered without having been dried. It is also very unusual for fragile woods to be given preservative treatment unless the customer expressly stipulates it.

Not only are the varieties of wood on the market limited in number, but their classification is very summary. In tropical Africa only two main categories of wood are recognized - red and white. Within this very broad classification, selections are usually imprecisely defined, and there seems to be no standardization in this field. Even sawmill throw-outs, which have none of the qualities of good, marketable timber, are sometimes sold locally to meet family needs.

There is a clear need for qualitative and dimensional classification. Government authorities should explain the importance of these measures to users and producers, for only thus can the market be put on a sound basis so that people may have confidence in wood as a material and tend to use it.

Outside the large towns, wood products (sawn wood, plywood, panel doors, flat doors, window-frames) are very badly represented on trade circuits. Possible purchasers have difficulty in obtaining these products, and are therefore disinclined to use them.

It would certainly be very profitable if producers in the African countries studied their distribution-circuits with a view to improving them. Their products would thus find their way to users more easily, and trade would grow. Such a study would probably show that certain products, which are at present too elaborate for the present market, and therefore too expensive for the possible purchaser, should be simplified. It might also show the advantages of a "do it yourself" solution, which would provide purchasers with basic elements. Such a system should be adapted to local conditions, habits and aptitudes. This solution seems suitable for countries where the people have small incomes but much spare time and abundant family labour. However, changes in selling methods are difficult, and presuppose a thorough market study.

2.2. Cost

2.2.1. Present price levels

It would be very difficult to give the prices of wood in all tropical countries within a short report like this, so we shall confine our attention to French-speaking tropical Africa, for which accurate figures are available.

The following table shows average 1966 prices for the broad summary categories of timber existing there. The prices include taxes and are ex-sawmill. They apply to sawn wood of all widths, generally less than five metres long, of all thicknesses, when sold by quantities of over one cubic metre:

Prices of sawn timber in CFA francs per m^3

	Cameroun (Yaoundé)	Congo (Brazzaville)	Gabon (Libreville)	Ivory Coast (Abidjan)	Central African Republic (Bangui)	Senegal (Dakar)	Chad (Fort-Lamy)
Shuttering for concrete-work	12,000 to 13,000	12,500 to 13,500	1[illegible],000	11,000 to 13,000	10,000 to 1[illegible],000	1[illegible],000 to 15,000	1[illegible],000 to 20,000
Local "red" woods	14,000 to 20,000	17,000 to 20,000	Okoume: 16,000 to 27,000 Others: 20 to 31,000	14,000 to 2[illegible],000	16,000 to 2[illegible],000	1[illegible],000 to 22,000	–
Imported "red" woods						20,000 to 25,000	20,000 to [illegible]2,000

This table shows the differences of price from one country to another. Transport costs seem to have great importance. In Chad, which is over 1,000km from production areas, shuttering wood costs twice as much as in the Central African Republic, where it is produced, and "red" woods cost half as much again as in Cameroun or Congo Brazzaville, which are the countries selling them at the lowest prices. The table does not show the fact that, within a given country, transport costs may make wood which has to be transported to a place 600 to 800km away from the capital 30 per cent more expensive.

All the above prices may be increased by as much as 40 per cent if the customer insists on fixed widths or lengths.

In general, prices of sawn wood appear high, especially when it is considered that the sale price of a cubic metre of "red" wood logs of sawmill quality varies according to species and accessibility from 4,000 to 6,000 CFA francs. If an average sawmill yield of 40 per cent is assumed, there is a great difference between cost price and sales price. This margin has several causes, some of which were discussed earlier and others of which will be considered in the next chapter.

This policy of high prices is unfortunately unfavourable to a development of the use of wood in building, the more so as the quality of the timber sold is not above reproach. It may be concluded that this high cost is mainly responsible for the poor competetiveness of wood with respect to other building materials.

2.2.2. Possible developments

The relative cost of sawn wood is not likely to increase in the years to come for the following reasons:

- Exportation of sawn wood should increase at the expense of that of logs, and as sawmill production rises, sawing costs should drop.
- To meet demands for increased production, sawmills would have to modernize their equipment, which would in many cases improve productivity and thus reduce costs.
- Because of the Africanization of supervisory staff, less European technical staff will be required in sawmills within a few years, and this will also reduce costs.

Finally, if a coherent policy for the development of wood use for building is applied, standardization of products will lead to mass production, and consequent lower cost.

There are thus grounds for hoping that wood will become more competitive with other building materials.

III. PROBLEMS TO BE SOLVED AND ACTION TO BE TAKEN IN ORDER TO DEVELOP THE USE OF TROPICAL WOODS AND THEIR DERIVATIVES FOR BUILDING PURPOSES

The large-scale use of wood for building is at present limited by many obstacles of various kinds. Its development is dependent upon action which must be undertaken in various sectors and at various levels.

In this chapter, we shall examine the problems which seem most urgent and suggest action which might eliminate certain difficulties and thus help to promote the use of wood for building.

3.1. Psychological aspect

3.1.1. Present situation

In many countries, and especially in tropical Africa, there is marked psychological opposition to wooden houses.

It must be recognized that this opposition is not baseless. Both town and country dwellers know, from experience, that wood sometimes has poor durability and is difficult of upkeep. They do not realize, however, that most of these drawbacks are rather due to the building techniques used than to wood as a material itself. Nevertheless, knowledge of wood has made much progress, thanks to the various wood research centres, and it is now possible to choose the most appropriate wood for each type of use and to erect it in the most suitable fashion.

Despite all the educational efforts that may be made to improve living conditions, especially among the poorer classes, it is to be feared that wooden dwellings will remain "poor man's houses" in people's minds for a long time to come.

Buildings made entirely of wood represent a sort of link with a tradition from which many people wish to break away, and most people think it prudent and modern to build houses of some hard, permanent material, which represents to them a symbol of duration and the visible proof of rising in the world. It is regrettable that these ideas should have been imported with this manner of building, which was generally used for the houses of the wealthy and for large buildings, formerly occupied by Europeans and now by the richer members of the local population.

These feelings have found support also because, so far, prefabricated wooden houses have generally been ugly, badly planned and harder to maintain than houses of the same standard made of other materials.

Fortunately, this opposition is much less marked in the case of the partial use of wood in buildings. In most cases, architects, contractors, the authorities and public opinion are not systematically opposed to the use of wood for interior and exterior fittings, which it is thought normal to carry out in wood.

3.1.2. <u>Action to be taken</u>

To reduce this psychological objection to wood is a long-term task, calling for considerable resources. This principle must be recognized, for any piecemeal and unco-ordinated action would be pointless and a mere waste of time and money. Only a plan of action spread over several years, carried on through the mass media (the press, radio, television) would be worthwhile. The public would be reached at all levels and informed of the real qualities of wood, its possible uses and its correct utilization, thus showing up the mistakes formerl made and proving the falsity of the commonly-held prejudices against wood.

This action would be effectively completed by the introduction of basic instruction on wood as a building material into primary school, popular education and rural improvement programmes.

However, no publicity campaign will have any change of success unless it can depend upon:

- The desire of the timber industry to develop production while trying at the same time to satisfy users to the maximum, especially by improving th quality of their products and diversifying them in a logical fashion;

- Pilot-projects which will provide actual examples of what can be achieved with wood.

Any action taken with a view to facilitate and encourage the use of wood in building at the administrative, financial and economic levels will help to increase confidence in this material and consequently do much to reverse the present psychological trend.

3.2. Technical aspect

3.2.1. Present situation

It is regrettable that wood is often erected in the wrong conditions. In this respect, the worst and, unfortunately, most frequent faults are:

- Use of undried, green wood, not stabilized to its conditions of use, leading to warping of assemblies and bad wear of finishes.
- Indiscriminate use of the various varieties of wood, and especially the use of those with low durability.
- Poor durability of pieces permanently subjected to bad weather or other sources of damp.
- Ignorance of preservative treatments, leading to the use of untreated or badly-treated wood; in the latter case, either the products chosen for treatment have been ill-chosen or are ineffective, or the treatment has been badly applied (insufficient product used, green wood).
- Over-generalized use of varnishes for exterior woodwork. This finish is certainly attractive on tropical timbers, but it has serious drawbacks: it is expensive, difficult to apply and lasts only a short while, calling for frequent, difficult and expensive upkeep. All too often this upkeep is neglected, leading to an unaesthetic appearance that causes passers-by to doubt the usefulness of wood as an exterior building material.

It is scarcely surprising that all these mistakes make people believe that wood is an easily warped, short-lived material, of short duration and which is difficult to maintain.

Furthermore, in forest areas, the range of varieties used amounts to little more than half a dozen, while it is even smaller in non-producing countries, where only two or three species are imported, and even then are generally of second quality. This limitation of range of varieties and quality on local markets runs counter to the rational use of wood by forcing people to use varieties and types which are only partly suitable to conditions of use.

The absence of any qualitative and dimensional standards makes it difficult to use wood in new sectors, or for long-term projects where steady supply is an important factor. The absence of standardization for certain pieces (such as flat doors or common frames, for example) is an additional obstacle.

3.2.2. Action to be taken

It is essential that action be taken in all countries where such mistakes are being made. The initiative must be taken by governmental authorities, especially those responsible for timber production (Ministries of Water Resource and Forestry in tropical African countries) and those representing large-scale users (Ministries of Works). These authorities should also enlist support from the wood-using industries and trades, as decisions taken jointly will gain much in effectiveness.

A standing committee or other specialized body of persons representing these different sectors should be established. It would make a continual study of the main problems concerning the use of wood, especially:

- The drafting of a set of technical specifications for the use of wood, to be made binding by application at least to public works projects.
- The laying down of qualitative and dimensional standards for sawn wood.
- Study of the standardization of certain commonly-used wooden building item
- The dissemination of technical knowledge among civil servants, architects and businessmen, with special reference to drying and finishing procedure
- The promotion of varieties not yet in use in order to enlarge the number of woods used in building.
- Study and advice concerning all large wooden constructions.

This body could also refer certain questions to specialized centres or technical institutes for study. Much time would be saved in this way, and the best possible solution to the problems could be found.

Thanks to this work, producers of sawn wood and woodwork could improve the quality of their products by strict obedience to the rules governing use and by using a wider range of species.

3.3. Architectural aspect

This item mainly concerns the construction of all-wooden houses in tropical African countries.

3.3.1. Present situation

So far, most of the contractors who have built wooden houses in West Africa have rarely called upon the services of architects. This has led to the following errors:

- Use of small wallboards, with consequent use of very many joint-covering battens both outside and inside, so that the houses look like temporary buildings.
- Excessive use of varnish both outside and inside, without any attempts at artistic effect by menas of assembly with other materials. The result is that the houses are often too dark-coloured and monotonous.
- No attention paid to the houses' surroundings, so that the wooden houses stand in unattractive surroundings.

3.3.2. Action to be taken

For wooden houses, joint teams of architects and technicians must be called in, just as in the case of other types of building. By working together, they will be able to produce rational and attractive designs. It would also be most desirable to pay attention to the surroundings in which the houses are to be set.

The first efforts in this direction have been successful, especially in Gabon where most attractive houses have recently been built.

3.4. Administrative aspect

3.4.1. Present situation

In many countries, and not only in developing ones, official regulations governing building either do not mention wood as a material or are mistrustful with regard to it. The development of the use of wood for building is hampered by the fact that specifications provide little opportunity for wood to compete successfully with hard materials such as bricks or concrete. This attitude sometimes leads, in large towns, to a refusal to grant building permits for all-wooden houses in the centre.

The most usual reason why public authorities do not favour the use of wood for public buildings is that it does not correspond to the customs of the country, or that those responsible for these matters have no confidence in wood as a building material. This leads to the statement often made by public departments housed in wooden buildings to the effect that their accomodation is only temporary, and will shortly be replaced by concrete constructions. It is easy to imagine the harm that this attitude does to wood as a building material.

3.4.2. Action to be taken

However, it is in the field of public building that the authorities could act most easily and effectively, had they an earnest wish to develop the use of wood for building purposes. A few simple and obvious measures doing away with certain prohibitions would have rapid effects. A few solutions are suggested here:

- Changing the administration's tender requests to permit the use of wood. For certain projects, it could be made obligatory to submit an alternative wooden version. Tenders could also be split up so that medium and small-scale firms could bid. In all instances, enough time must be given to contractors between the signing of the contract and the beginning of construction for them to dry their wood; otherwise, as all too often happens, the use of this material is condemned in advance by reasons of the defects which too short a construction deadline inevitably entails.

- Establishing acceptance procedures for standard designs for wooden buildings. This would avoid obstacles arising from restrictive regulations and facilitate housing loans.

- Studying standard designs for such buildings as schools, dispensaries, and low-cost housing incorporating the use of mass-produced wooden elements, thus enabling wood to compete with other types of construction, which often involve the use of imported materials.

- Strict checking of wooden parts used in all buildings to see that they correspond to specification. This would guarantee a minimum life, and limit the risks run by building-societies.

In the first place, such checking could be applied to public buildings, an important sector where its application would be fairly easy. It could later be extended to all buildings by making it mandatory whenever loans were to be granted.

3.5. Financial aspect

This item deserves special attention. In developing countries, where incomes are low, housing-loan policies can have great influence on the methods of building.

3.5.1. Present situation

It appears that, in most of these countries, although there is no systematic withholding of credit from wooden buildings, neither is there any encouragement for them. Paradoxically, in African wood-producing countries they are at best treated on the same footing as concrete buildings, although concrete construction usually involves imported materials.

It is equally true that no special financial facilities are granted to composite buildings using a high proportion of wood.

Loan organizations do not take account of building techniques or of the materials used. Their policies are based on the guarantees of refund offered by the borrower (a sufficient wage, and usually some stability of employment) and on the presumed durability of the building, which must be equal at least to the length of the loan.

3.5.2. Action to be taken

The governments of forest countries should encourage housing-loan agencies to favour the development of wooden housing, or at least of housing incorporating a considerable proportion of wood. This policy must, of course, be accompanied by an obligation for builders to respect certain minimum standards for the use of wood, so that suitable technical guarantees could be provided.

It is almost certain that this financial encouragement alone would be enough to bring about an improvement in the quality of wooden housing by opening up important markets.

3.6. Economic aspect

3.6.1. Present situation

The details of current prices given in a previous chapter show that in all Central and West African countries the prices of sawn wood and wooden construction-elements are high. Unfortunately, this is often true in all developing countries, for many reasons such as insufficient industrialization, absence of market studies, poor distribution circuits, etc.

The price factor is certainly the one which does most to limit the development of the use of wood for building purposes.

These sometimes excessive prices are usually due to agreements between producers, or to bringing prices into line with those practised by the main producer. This absence of a competitive market jeopardizes the use of wood, because it not only limits the quantities sold, on account of high prices, but also makes for the marketing of poor-quality timber.

In addition, users of sawn wood who do not possess their own factories sometimes encounter supply problems because sawmills run out of stock as a result of trying to tie up the least capital possible. Moreover, users of sawn wood who are situated outside production areas also have supply problems caused by the uncertainty and high cost of transport over long distances.

Finally, in most developing countries the quality of goods is not controlled, competition is slight and the consumer is not always very demanding. In consequence, businessmen in these countries are less careful than those in developed countries about quality control, improved workmanship and cost calculations.

These differences in trading conditions may partly explain a certain slovenliness and lack of desire for improvement. Unless these faults are overcome, however, it would be in vain to attempt to encourage the use of wood for building.

3.6.2. Action to be taken

Various measures could be suggested for changing the present situation, but no result will be forthcoming unless there is understanding and active co-operation by the trade itself. If imposed from above, action would encounter a hostility that would only lead to still higher prices. If the measures were properly explained and understood, however, they would be a stimulus to trade, making matters easier for producers and solving their problems. Among such steps, the first might well be:

- Standardizing products (for example, standardizing flat doors and common types of windows);
- Mass-production instead of production to order, as far as possible;
- Charging higher prices for non-standard products in order to dissuade customers from buying them.
- Reorganizing certain workshops for mass-production (this would often involve the replacement of worn-out equipment);
- Study of wooden buildings to see whether industrial prefabrication could lead to substantial savings, especially in the case of large-scale housing or school-building programmes.

Government authorities should also intervene to prevent any unwarranted price-fixing and to keep an eye on the evolution of local market prices.

3.7. Professional training aspect

This is often neglected, although it is of vital importance, for only mistakes can result if a material is used by workers who do not know how to treat and install it. Wood is often blamed for faults arising from the workmen's incompetence. Hence, there can be no development of the use of wood if nothing is done to train woodworkers.

3.7.1. Present situation

In developing countries, the training of workers and overseers is usually carried out on the job. This is true of wood industries also. This type of training is fairly easy at the worker level, but when it comes to overseers, problems of literacy which firms are not always able to solve may arise.

Sometimes such personnel are trained in public or private institutions. The results are not always those expected, however, because most of the young men who receive diplomas turn to administration rather than industry or craftsmanship. Attempts to give practical complementary training have recently been made in the Central African Republic and Congo (Brazzaville) with the help of the United Nations Special Fund.

Much remains to be done by the public authorities to provide training for workers, overseers and craftsmen in the woodworking industries.

As far as senior personnel are concerned, training problems are not at present met with to any great extent, as so few such personnel are as yet required. Training has therefore been carried out so far in schools and specialize centres in Europe.

3.7.2. Action to be taken

The development of the use of wood requires skilled personnel at all levels. Such personnel are needed for the wood industries and the timber trade, while small craft workshops must also be set up to serve the small towns and the countryside.

Developing countries, therefore, must attach special importance to the training of skilled workmen and wood technicians. Training should not only cover wood techniques, but also give at least some of the trainees some idea of the organization of work and the management of small businesses.

3.8. Conclusions

All these measures are merely part of an overall policy for the development of a private sector, based on a better use of national or regional natural resources. Obviously, measures which interlock must be co-ordinated, and be maintained for a sufficient time for wood to become the customary construction material, at least in those developing countries which have forests and a timber industry able to exploit them.

The pursuance of this policy may call for outside assistance in some countries. Its success will depend mainly on the governments' desire to succeed and on the interest shown by private enterprise.

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