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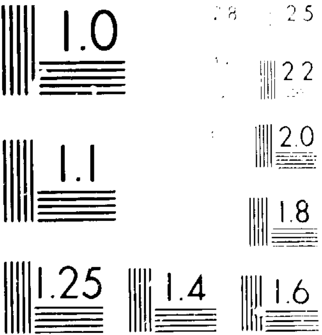
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org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WOOD RESOURCES AND THEIR USE AS RAW MATERIAL

M. de Bakker
Potter
J.S. Bethel

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Preface

This study has in its entirety been prepared by the Forestry Department of the Food and Agriculture Organization of the United Nations for the use of the Sectoral Studies Branch/Division for Industrial Studies/UNIDO in the First World-wide Study of the Wood and Wood Processing Industries, UNIDO/IS.398. UNIDO is thankful for this valuable contribution and expresses its appreciation for such interagency co-operation in practice.

Section 1 is based on the work of M. de Baker, section 2 on the work of Mr. Potter and section 3 on the work of J.S. Bethel.

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SECTION 1: WOOD RESOURCES AND THEIR USE AS RAW MATERIAL

1.1 Review of forest resources

1.1.1 Review of the world forest resources

Nature bestowed this world with abundant forest resources, but 40 centuries of "civilisation" have altered this situation. The forest, from nature's point of view, is a protective cover for the soil. People use the forest for satisfaction of their needs, but seem to have become aware only recently that the proper protective role of the forest and the satisfaction of material product needs are not necessarily coincidental.

FAO has undertaken periodic assessments of the state and evolution of the world's forest resources and published world forest inventory studies in 1952, 1958 and 1963. Since then, assessments have been made on a regional basis to update and improve the world-wide data base.

A new forest resource assessment was recently completed for all tropical forests by FAO through a FAO/UNEP project. A perusal of selected information from this world-wide data bank on forest reserves, which has some limitations, provides information as to the present state of the world's forest cover and its utilization and contribution to society.

This paper, while reviewing the forest resources available in the world today, aims to provide some insight into the industrial development potential of these resources and into the constraints that up to now have impeded their full utilization. Such utilization has to conform to many parameters of an economical, social and technical nature that, theoretically, would optimise the use of the forest for the benefit of the whole population. Some practical constraints, however, can reduce utilization significantly, and some of these factors may in fact threaten the very existence of the resource.

The total forested area of the world is about 4 100 million ha, (table 1.1), covering some 30 per cent of the world land area. Technically two types of forest can be distinguished. The first is the closed forest, which has a closed tree canopy. The second is "other wooded land" in temperate regions or open forest in tropical regions, where trees predominate but without constituting a full tree capony. The closed forests cover about 3 000 million ha, of which 1 600 million ha are in the temperate zone, and 1 200 million ha in the tropical regions. The total volume of growing stock in the closed forests is estimated at some 330 000 million m^3, of which 145 000 million is in the temperate regions and about 185 000 millions m^3 is found in the tropical forest.

Table 1.1 The world's forest resources

Regions	Population	Area in million ha		Volume 1 000 million m^3
	million	All forest	Operable forest	Growing stock operable forest
Developed	1 164	1 910	940	96
Developing:				
Temperate	1 189	1 015	150	12
Tropical	2 062	1 200	885	162
Total Developing	3 251	2 215	1 035	174
Total World	4 415	4 125	1 975	270

The "other wooded land" covers about 400 million ha in the temperate zone and 750 million ha in the tropical areas. Estimates of the total volume of growing stock of those "other forests" put this at 20 000 million m^3, two-thirds of which is in the tropical areas.

However, this is not all suitable for forest industrial uses, as indicated in Table 1.1. In fact, less than 50 per cent of the total forest area is suitable for this purpose, though this does contain 77 per cent of the world growing timber stock.

This paper will continue its analysis in terms of its stated objective to describe the forest industry development potential. It may, however, be useful, and even necessary, to draw attention to the wide range of other tangible forest non-wood products, and to the wide series of less tangible benefits that a society derives from its forest.

Forests not only produce wood but also an impressive range of products such as branches, bark, nuts, roots and leaves that may be used in one way or another by people, or serve as feed for cattle or for the forest fauna in general. Its ecological characteristics, as a self-sustained biomass, provide many products highly appreciated by society (at any stage of development) be it the amenity values of its environment, the shelter against the sun, the opportunity to the hunter and, last but not least, its regulatory functions in terms of rainfall, climate and erosion control. All these products and values, some of them difficult to quantify, will not be referred to in the rest of this paper, but need to be kept in mind whenever assessing the contribution of forests to humanity.

The above broad quantitative picture indicates the comparative importance of the forests of the temperate and of the tropical regions. On a quantitative basis, the volume of standing timber in the "closed forest" averages 80 to 100 m^3 per ha in the temperate regions, while in the tropical regions volumes range from 100 to 200 m^3 per ha or more. The difference is due to the more active bioclimatic conditions of the tropics.

Complementary to this quantitative distinction, there are other important characteristics of coniferous and broad-leaved forests which will be covered in detail in the coming paragraphs. The coniferous forests cover some 75 per cent of the forest area in the temperate and north regions, versus only 2.5 per cent in the tropical regions. They are mainly evergreen forests occuring in homogeneous stands, generally with one predominant species. The non-coniferous or broad-leaved forests present distinctly different characteristics in the temperate regions as compared with their characteristics in the tropical regions. In the temperate regions they occur as associations of a few species, with common sylvicultural aspects. The tropical broad-leaved forest, on the other hand, is characterised by a generally heterogeneous mix of hundreds of species, with only a few cases of a single species, or species group, predominating. These technical characteristics have far reaching consequences on their utilization.

1.1.2 Forest resources in the developed countries

Area and growing stock

The forest and other wooded areas in the developed countries cover some 1 900 million ha, or somewhat less than 40 per cent of the total land area. If one deducts the "other wooded areas" with only limited tree coverage, a total forest area of some 1 500 million ha remains. However, for an analysis of the potential contribution to forest industries, it is necessary to separate the wide area of forest that is not operational for a variety of reasons, such as physical or economic inaccessability, or a variety of legal constraints designed to preserve the forest for its protection potential. Thus the amount of forest available for roundwood production in the developed regions amounts to about 940 million ha, referred to in this paper as operable or productive forest.

Table 1.2 The productive forest resources of the developed world

Regions	Area in million ha	Volume in 1 000 million m^3	
	Operable forest	Total	Coniferous
North America	366	36.4	26.6
Europe	131	14.1	8.8
U.S.S.R.	389	40.0	33.2
Other	54a/	5.5	3.9
Total developed	940	96.0	72.5

a/ Derived figure

The total growing stock, given as the bole volume of all trees, is estimated at about 140 000 million m^3 for all the closed forest, while the figure for the closed operable forest is about 96 000 million m^3, of which North America, Europe, and the USSR together account for some 90 000 million m^3. These volumes represent the productive forest capital of the developed world.

Botanical composition

A broad general description of the botanical composition of the forest is necessary at this stage to illustrate some of the major characteristics of the forest industries of the developed world. The coniferous species represent more than three quarters of the total growing stock in the operable forests.

Geographically the coniferous species are predominant in the colder climate of the north, and in the higher altitudes in the south. Moving south, the broad-leaved species appear and gradually replace the coniferous species as the dominant forest types. As population densities are low in the north, these relatively undisturbed large coniferous forests offer a substantial potential to the forest industries.

Institutional framework

Ownership and legislative framework are two important aspects that regulate the potential use and management of the forest. In the developed world, a complex and very diversified pattern of ownership and management has emerged. In the planned economy countries, the forest is directly and totally linked with the production and planning activities of the State, and it is vested in the forest authorities responsible for the operational or managerial aspects. In the market economy countries the situation is rather diverse, as can be seen below, but it should be mentioned that, whatever the institutional system, practically every country has realised the need for a forest policy with adequately balanced short and long-term goals. Moreover these goals increasingly cover objectives in which roundwood production only represents a part of the total output.

The paper now summarizes the situation in the main regions.

North America

The situation in Canada is very different from the USA. There are vast areas of coniferous forest in the thinly populated parts of Canada, with the big market for its products lying in the USA. The inventory data covering the forest resources of these two countries is not necessarily equivalent but a broad comparison can be made.

Both countries have about the same forest area - Canada 325 million ha, and the USA about 305 million ha - which represents in both cases about 35 per cent of the total land area. A significant difference lies in the population data: Canada has 25 million people and the USA has 225 million. Both countries also have roughly the same growing stock of standing timber at around 22 000 million m^3, though in Canada this is 80 per cent coniferous forest, while in the USA it is 65 per cent.

The growing stock per ha in Canada is about 70 m^3/ha while in the USA this figure reaches over 100 m^3/ha. Net annual increments in Canada are estimated to be about 1.1 m^3/ha, or 1.5 per cent of the growing stock, while in the USA it is about 3 m^3/ha, or 2.8 per cent of the growing stock, reflecting the more southernly location of the USA.

With regard to public ownership, sharp differences occur between the two countries. Public ownership in Canada accounting areawise for 92 per cent ofall closed forest, while in the USA 27 per cent of the productive forest is in public ownership and 73 per cent in private ownership. One third of the private forests belongs to farm owners, one sixth to industry, and about half to an "other" category which includes many small owners.

Europe

Europe has an area of forest and other wooded land of 175 million ha, representing slightly more than 30 per cent of its total land area. This percentage is much higher in the Nordic countries (52 per cent) and lowest in the ten EEC countries (22 per cent), in inverse ratio to the population densities. Of this total forest area, 131 million ha of forest are considered operable for industrial production.

On average 53 per cent of the forest in Europe is in public ownership with the lowest proportion in the Nordic countries (less than 25 per cent), about 75 per cent in Southern Europe and 92 per cent in Eastern Europe.

Management plans cover between 85 and 100 per cent of all publicly owned forest, except in Southern Europe. For privately owned forest, management plans exist for little over half the area in the Nordic countries and Western Europe. However, the other operable forest is practically all covered by some cutting regulations.

The total growing stock of the operable forest is estimated at about 14 100 million m^3, of which 63 per cent is coniferous. This represents an average growing stock per ha of about 108 m^3/ha for Europe, but with wide extremes on a country-by-country-basis; 85 m^3/ha in the Nordic countries, 100 m^3/ha in the EEC, 250 m^3/ha in Central Europe, and 150 m^3/ha in Eastern Europe.

Net annual increment averages about 3.3 m^3/ha, or 3 per cent of the growing stock, with the highest nearly 6 m^3/ha in Central Europe, and the lowest 2.6 and 2.9 m^3/ha in Southern Europe and the Nordic countries respectively.

U.S.S.R.

The forest resources of the USSR are enormous and are spread over vast northerly sub-temperate areas, while population is mainly concentrated in the west and south-west of the country. This gives an indication of the difficulties inherent in the exploitation of this vast resource, where its utilization potential is limited by severe climatic conditions and, in many cases physical inaccessibility. The official statistics of 1975 give an indication of this potential.

Some 785 million ha or 43 per cent of the total land area is classified as forest area. Of this, 389 million ha are considered operable at present, being physically accessible and with logging plans.

The total growing stock of all forests is estimated at 74 700 million m^3 which could mean that the growing stock of the operable forest is around 40 000 million m^3. The growing stock per ha is estimated to be around 103 m^3/ha, and the annual increment around 1.2 m^3/ha, or about 1.2 per cent of the growing stock. Coniferous species represent about 83 per cent of the operable forest stock.

Other areas

The remaining areas in the developed world are diverse and not very significant in terms of productive forest. This includes Japan, Oceania, Israel, and South Africa, which from the forest resource point of view do not have a common characteristic. Perhaps the most significant feature could be Japan, with its high population and limited forest resources, which has developed an important wood industry based on imports from both developing and industrialized countries.

1.1.3 Forest resources in the developing countries

To give a brief analytical description of the forest resources of the developing world requires a summary of widely diverse situations, even when concentrating on those aspects which would be relevant to the forest industry development potential which is the stated objective of this paper.

For this section, estimates based on the documentation available for developing countries with temperate climate zones have been added to data obtained in the recent FAO/UNEP Study on Tropical Forest Resources to provide the total picture for developing regions. Thus, estimates for Chile, Argentina, and Uruguay have been included in the totals of Latin America, data for the Maghreb countries in the totals for Africa; data for Turkey, Iran and

Afghanistan in Asia New East; and such data, as available, for China Mongolia and both Koreas in the group of East Asian countries. The data for these countries is not always recent but where such data is not fully comparable with the FAO overall world data, this is mentioned.

Forest inventory data coverage for tropical forests is not always strictly comparable to that for the temperate forests. Historically many inventories of tropical forests only covered the "commercial" species that could be marketed, using specific demand assumptions as well as a hypotheses about the physical availability. Data for this concept is given in the mentioned FAO publication as a special table - VAC (volume actually commercialized) - as a reference. The growing stock volumes used in this paper give the VOB (volume of bole) of all species, disregarding quality and potential utilization. The utilization potential is duly examined, however, as one of the essential parameters in assessing the industrial development potential.

This VOB concept is valuable for assessing the potential utilization as sawlogs and veneer logs, given due regard to species. It needs to be stressed that, in addition to the bole, branches can also be used as fuelwood, or as pulpwood. Branches have been estimated, on the basis of several measurements, to represent about 40 per cent on top of the VOB in the closed forest. For "other wooded areas" it could well be more than 40 per cent.

In this respect the forest classifications used below for the tropical forest is not strictly comparable with the classification of temperate forest resources, though it is only a matter of degree. The closed forest concept used for the tropical forest is in fact more restrictive so that some of the "closed forest" of the temperate zone would inevitable have fallen in the "other wooded land" category if it had been in the tropical regions. This is not, however. of fundamental importance to this paper except to explain the relative importance of this category in the tropical regions.

There is also a difference in the use of the term "productive" forest which is conceived as all closed forest for which no restrictions exist on timber utilization whether due to stand and terrain conditions and/or to regulations. This means that distance as a factor of economic inaccessibility has for several reasons not been introduced. This was taken into account in considering the positions in the developed countries, especially in Canada and in the U.S.S. R. and it will also be in the analytical review below for each of the regions.

One of the standard tools in temperate forestry - the "net annual increment" (NAI) is an entirely theoretical concept with regard to the tropical forest. In the "untouched" climax tropical forest, whithout human interference, the NAI is theoretically zero, and is often so in practice. Human interference can have many influences, from destroying the forest - where not only NAI but also the capital becomes zero - to utilizing the forest, and even "managing" it, where the positive NAI again appears. Measurements in this field are, however, still insufficient to provide data for analytical use on a broad basis. Therefore, with these limitations in mind NAI estimates are only mentioned for reference purposes.

Finally, attention is drawn to the fact that the tropical closed forests of the world are disappearing at a rate of some 11 million ha a year. The forest industry is sometimes incorrectly blamed for the destruction of forests. Certainly it could sometimes gain from using more careful practices. The main cause for the depletion of the forest is man's need of land for planting food crops. Society in some cases may disregard the wood potential of the forests for a variety of reasons and interests, some good some less good, that may warrant closer scrutiny.

Latin America

The forest resources in Latin America cover some 930 million ha of forested land, of which 690 million are considered to be closed forest. These forests serve a population of 370 million inhabitants in a total area of

20 million km^2, 17 million km^2 of which are in South America. The area has a tropical climate down to the tropic of Capricorn, but colder regions are also found in the mountain ranges along the Pacific Coast. Areas and growing stock in operable forests are given in Table 1.3.

Table 1.3 The productive forest resources of Latin America

Sub-regions	Area in million ha Operable forest	 Under management	Volume of growing stock in million m^3
Central America	38	.3	3 782
Caribbean and Caricom	36	.2	7 252
South America-tropical	447	..	67 603
South America-temperate	9	..	1 200
Total Latin America	530	.5	79 837

For easy analysis Latin America has been sub-divided in four geographical regions.

Central America

This sub-region covers the countries on the American continent from Panama to Mexico; it includes seven countries with a total area of 2.4 million km^2 and a population of 93 million ($38/km^2$). Mexico by itself represents 80 per cent of the land area and 75 per cent of the population. The northern part of the sub-region in Mexico has a transitional vegetation of sub-tropical and temperate species.

The closed forest covers an area of 64.9 million ha, of which 38.5 million ha are considered to be productive, though with only about 300 000 ha under management in Nicaragua and Honduras. Mexico has more than 60 per cent of the productive forests of the region. In total, 14.2 million ha or 37 per cent of Mexico's productive forest are coniferous, and these represent 93 per cent of the productive coniferous forest in Latin America. These forest resources include some 1.5 million ha of mangrove forest, of which three quarters are in Mexico and Panama.

The total growing stock of all "closed forest" is estimated at 5 200 million m^3. Some 3 800 million m^3 of this is in the productive forest, which has 1 100 million m^3 of coniferous species.

Growing stock for broad-leaved species reach 110 m^3/ha while those for coniferous species average about 75 m^3/ha, but in some areas averages are reported to be near 200 m^3/ha.

The total area of plantations has reached about 185 000 ha, of which about half are stocked with coniferous species. The annual rate of planting seems to have topped 30 000 ha. Over half of the plantations are of the industrial type.

Deforestation, on the other hand, has reached an annual rate of almost 660 000 ha in the closed production forest.

Caribbean and Caricom

This sub-region includes the Caribbean islands and the countries of the Northern Atlantic Coast of the South American continent. It covers an area of 0.7 million km^2 with a total population of 27 million. It is a fully tropical coastal region with constant high temperature and humidity. Annual rainfall averages between 2 and 2.5 m, and the region has no high altitude areas. At present forest resources are concentrated mainly in the countries on the coast of South America, where density of population is low. Soils in the islands are volcanic and fertile.

The total area of closed forest is estimated at 46 million ha, of which some 36 million ha are considered productive. More than 33 million ha of these are found in Guyana, Suriname and French Guyana, and some 0.4 million ha are of coniferous species, half of them in Cuba. The total area of mangrove adds up to 825 000 ha.

The total growing stock of all closed forest is estimated at some 8 000 million m^3, of which some 7 250 million m^3 are considered to be in productive forest This data would indicate an average growing stock per ha of nearly 200 m^3/ha, which seems a fair indicator of its potential, and some areas of higher density are known. The growing stock is almost exclusively of broad-leaved species but with a wide range of those species.

In total some 200 000 ha of plantations have been reported, but more than three quarters are in Cuba, and half are stocked with coniferous species. The annual rate of planting is about 18 000 ha, of which two-thirds is with conifers.

Total deforestation is low; only about 23 000 ha per year.

South America - North (Tropical)

This sub-region covers South America north of the tropic of Capricorn; it includes 7 countries with a total area of some 13.5 million km^2 for a population of 200 million inhabitants; a density of 15 inhabitants per km^2.

The area is characterized by the large forested Amazon basin with savannah areas to the south and east, and in the west the mountain range of the Andes. In the lowlands, temperatures are high, between 20° and 30° C, with annual rainfall between 1.5 and 2.5 m, with a dry season gaining in importance to the south. To the west the Andes mountains have lower temperatures and decreasing rainfall, and even further to the west desert conditions prevail.

The Amazon basin, by far the largest tropical broad-leaved forest in the world, stretches out over some 550 million ha, and some ' countries - Brazil, Bolivia, Peru, Colombia and Venezuela - though the largest area is in Brazil. It has a low population. More than 70 per cent of the basin has a widely developed river span, which is tidal up the Amazon river for about 2 000 km, and flooding is not uncommon.

The total area of closed forest is estimated at some 570 million ha, which represents 80 per cent of the total Latin America forest resources. Of those forest areas, some 450 million ha are considered productive, and this represents some 40 per cent of the world's productive forest reserves; with 300 million ha in Brazil. These forests are practically all of broad-leaved species, with only a few exceptions such as the Parana Pine forest in Brazil and the Podocarpus forest in Peru. This region also has some 3.5 million ha of mangrove forest. The dominant type of ownership is public, though this is influenced by historical and local factors. The coniferous forest in Brazil is in private hands.

The total growing stock of these closed forests is estimated at some 78 000 million m^3, of which 67 600 m^3 are in the productive forests. 47 000 million m^3 of this operable timber is in Brazil. This gives an average growing stock of some 150 m^3/ha, but in some areas volumes of between 200 and 250 m^3/ha are reported, with even higher volumes for the Parana Pine.

With big development schemes, and localized population pressure, the rate of annual deforestation has reached roughly 3.3 million ha, of which some 2.5 million ha are productive forests. Moreover, that rate of deforestation is expected to increase. On the other hand, the rate of reforestation is impressive. By 1980, the total area of plantation in South America had reached 4.2 million ha, of which 91 per cent was in Brazil. The annual rate of planting by 1980 was somewhere near 450 000 ha, again mainly in Brazil.

South America - South (Temperate)

This sub-tropical to temperate sub-region covers an area of 3.7 million km^2 with a population of 41 million people. The area of productive forest is estimated at 9.1 million ha. Volume density estimates for the growing stock range from 50 to 70 m^3 per ha. Practically all the natural forest is broad-leaved, but the quality is not very high. A decreasing volume per ha is evident when going South and forest fires are a serious danger. None of the natural forest is under management.

The plantation programme has been substantial and the total area has reached some 1.5 million ha, of which about 60 per cent are coniferous. More than 80 per cent are industrial plantations and about 20 per cent fuelwood plantations. The annual rate of formation of industrial plantations has reportedly reached 80 000 ha. Growth rates of some 20 m^3/ha for the coniferous species (mainly Pines) and 15 m^3/ha for the broad-leaved species (Eucalyptus) are also reported. These plantations have considerably increased the forest potential of the region.

Africa

Table 1.4 The productive forest resources of Africa

Sub-regions	Area in million ha: Operable forest	Area in million ha: Under management	Volume of growing stock in million m^3
Northern	0.5	..	265
West and Central	148.9	1.2	37 300
East and South	12.3	.6	1 200a/
Total Africa	161.7	1.8	38 770

a/ data incomplete

The Mediterranean

This sub-region, covering the North African Mediterranean belt, with a population of about 90 million, has very little forest except in the Maghreb countries; the forests being mainly broad-leaved with some coniferous species. The growing stock is estimated to have a volume of about 60 m^3/ha for the 100 000 ha of managed forest; The rest of the region has xerophytic to desert conditions. The annual planting programme is estimated at some 20 000 ha and is mainly oriented towards fuelwood production.

Northern Savannah

In this sub-region with 30 million inhabitants, desert conditions prevail in the northern part, replaced in the transition belt by tree savannah associations. On the southern fringe some forest associations of the Sudano-Guineaese type appear that have some growing stock of sawlog size, but with a limited forest industry potential.

The area of closed forest is estimated at some 44 million ha, of which about 6.7 million ha are considered productive with a growing stock of 265 million m^3, or less than 40 m^3/ha. More important is the wider area of wood vegetation, all xerophytic associations estimated to cover some 130 million ha and producing fuelwood, wood in the round and many other non-wood products.

The total area of plantations is estimated at 37 000 ha and the annual rate of planting is 8 000 ha, all with broad-leaved species.

West Africa

This sub-region along the northern coast of the Gulf of Guinea, covering nine countries with a total population of 115 million over an area of 2.1 million km^2, has tropical evergreen forest vegetation along the coast where the rainfall is high. This decreases as one goes inland. The total area of closed forest covers some 18 million ha, of which only 11.3 million ha are considered productive. Also only 1 million ha are under management. Of the 6.6 million ha of unproductive forest, 5.6 million ha are inoperable for physical reasons which include poor quality as well as inaccessibility.

Total growing stock in the closed forest is estimated at about 2 900 million m^3, of which roughly 2 000 million m^3 are inproductive forest. This gives a volume of about 177 m^3/ha, but a number of forests in Ghana and Nigeria have volumes between 200 and 200 m^3/ha indicating the potential of some of the forests. However, some 63 per cent of the forests have been logged over, which influences both the volume and the quality of the remaining potential.

Data about growth rates are not readily available as most information covers increment of specific "commercial" species rather than total increment data. This problem is referred to again in the next paragraph, but figures between 1 and 2 m^3/ha for total growing stock are often cited for closed humid tropical forest. Intensive forest management does not seem to exist on a large-scale in this region.

The total plantation area is estimated to have reached 330 000 ha, 70 per cent of it in Nigeria, and the annual rate of planting at present seems to approach some 37 000 ha. The coniferous component is negligible.

Deforestation is calculated to reach about 720 000 ha annually, of which 300 000 ha occurs in Nigeria, and 290 000 ha in the Ivory Coast. As a response the authorities have decreed a new law protecting the forest estate.

<u>Central Africa</u>

This sub-region covers an area of 5.3 million km^2, embracing seven countries with a total population of some 49 million inhabitants, and it includes the large humid tropical forest of Central Africa.

The total area of closed forest covers some 173 million ha, of which 138 million ha are considered "productive". This is practically all tropical evergreen forest and a large part of it, the "Cuvette Centrale" of Zaire, still has an enormous potential, given a solution to the transport problem.

The total growing stock in Central Africa is estimated to reach nearly 40 000 million m^3, of which somewhat more than 35 000 million m^3 are in the "productive" closed forest and some 4 400 million m^3 in the unproductive forest. The productive forest is thus very rich volume-wise, with an average of around 250 m^3/ha, and stretches out from Central Zaire into the Central African Republic, Congo, Gabon and Cameroon. The main types of homogeneous forest are the Brachystegia and Gilbertiodendron formations around which some rich semi-deciduous forms are found with species of generae such as Crysophyllum, Antiaris, Entandophragma and Guarea. Aucoumea is further found in Gabon. In general, the species mix in these forests is very high with some regular botanic associations but often with widely diverse technical characteristics. None of these forests are managed. There are practically no coniferous forests.

Data about growth rates is not readily available. Most of the information available is about specific "commercial" species, and such studies reveal that growth rates are strongly influenced by the environmental conditions, often determined by the availability of light, though many species are shadow tolerant at the early stage. It is therefore difficult to give a general figure that could be applied to the growing stock data.

The total area of plantation is estimated to be around 235 000 ha, of which more than two-thirds are in Angola, but the present rate of planting is very low. Annual deforestation, on the other hand, is reported to be around 350 000 ha, mainly in Zaire and Cameroon.

East Africa

This sub-region lies between the Great Rift and the Indian Ocean. It covers an area of 5.8 million km^2 with 8 countries and a total population of about 110 million inhabitants. The climate is warm except for some cool night temperatures in the dry season and in the higher altitudes in Ethiopia, Rwanda, Burundi and Kenya.

The total closed forest area is about 9.7 million ha, of which about 4.0 million ha are classed as productive. Many of the unproductive forests have poor growth because of poor terrain and stand conditions. Some 1.1 million ha of the forests are coniferous, of which about 60 per cent are productive; they are important in Ethiopia and Kenya.

Total growing stock of the closed forest is estimated to be over 900 million m^3, of which 400 million m^3 is productive forest. About half of the forest is undisturbed and forest management plans exist for only about 15 per cent of the area. The growing stock of productive coniferous forest is 65 million m^3. Some humid closed mountain forest is reported to have volumes per ha of over 200 m^3, but the overall volume per ha in this region is low. For the open forest areas it can be between 40 and 80 m^3/ha, and for the mixed tree forest grassland formations between 20 and 30 m^3/ha.

There is insufficient information about the increments in these forests. Figures of 0.4 m^3/ha/year are used in Kenya and Uganda.

The total area of plantations is estimated to be some 650 000 ha, most of which is in Sudan, Kenya and Ethiopia, and the annual rate of plantations is about 35 000 ha. On the other hand, the annual rate of deforestation is only about 60 000 ha.

Southern Africa

This sub-region covers an area of some 3.5 million km^2 of land, with seven countries, and a population of 30 million people. Climatically it is sub-tropical and the terrain ranges from desert in Namibia to humid tropical mountain forest in Madagascar.

The total area of closed forest is about 15 million ha, of which about 9.0 million ha are considered productive, with 650 000 ha under management. More than two-thirds of these resources are in Madagascar and none in Zimbabwe, Botswana and Namibia. The tropical forest in Madagascar has more than 150 different species varying with altitude. Afzelia, Caliphyllum, Canarium and Dalbergia are reported. 750 000 ha of mangrove forests are found in Madagascar and Mozambique. No coniferous forest is reported.

Total growing stock in closed forest is estimated at 1 100 million m^3, of which 770 million m^3 in productive forest, but average volumes per ha are not very high. Nevertheless, over 200 m^3/ha have been found in some areas.

Asia

The forest resource in Asia, continental Asia and the S.E. Asian archipelago covers some 600 million ha of forested land, of which some 425 million ha are considered to fall in the category of closed forest. These forests serve a population of some 2.4 million inhabitants over a total land area of 27 million km^2. The productive forest resources are shown in Table 1.5.

Table 1.5 The productive forest resources of Asia

Sub-regions	Area in million ha Operable forest	 Under management	Volume of growing stock in million m^3
Asia Near-East (Te)	15a/	..	1 830
East Asia (Te)	125	n.a.	9 700
South Asia	48	33.1	3 840
Continental South-East Asia	39	3.4	6 650
Insular South-East Asia	111	2.4	21 000
Total Asia	338	..	43 020

Te: Temperate region
a/ incomplete

West Asia and the Near East

This sub-region has a total population of some 135 million and, due to low humidity, is characterised by a limited forest cover that has also suffered the impact of human pressures. At present, some forest resources remain in a few countries and provide some roundwood for local industries and consumption, but in general their utilization for industrial purposes is definitely below potential.

East Asia

This sub-region consists of China, Mongolia and the two Koreas, among which China, in terms of land area, forests and population, has a predominant position. China, a country with basically temperate conditions, extends over a vast area with wide ranging climatic and ecological conditions. It is reported to have a total of some 120 million ha of forest, including sizeable areas of plantations. The forest resources have been used intensively and practically all of those situated within a reasonable distance of the populated areas are reported to be under working plans. Statistical details are, however, not readily available. With the existing population pressure and the prominence given to rural development, the degree of utilization of the existing forest resource is high, and planting has been undertaken to keep the resource potential in line with utilization, while balancing the claims of present and future requirements. Both distribution and utilization aspects are reported to have been developed using technology appropriate to local conditions. In view of the enormous wood requirements of the vast population, and taking into account the present state of the forest resources, it appears to be accepted that the present forest estate, covering only 12 per cent of the total land area, is insufficient to meet the prospective demand for wood and forest products. A huge plantation programme is thus envisaged to cover these needs.

South Asia

Ecologically the forest resources in this sub-continent, which has a population of some 850 million, are similar to the preceding region, if onlybecause of the high population density. On the other hand, though it is located mainly in the sub-tropical and tropical belt, it is only in the southern part that any important area of humid tropical forest still exists.

The forest in this sub-continent can be described as belonging to six major types. There are the moist and the dry tropical forests, the montane sub-tropical, the wet temperate and the sub-alpine forests, to which should be added the bamboo and the mangrove forests (some 0.85 million ha).

The area of closed forest is estimated at some 60 million ha, of which about 48 million ha are considered productive. The total growing stock is estimated to be near 4 400 million m^3, of which about 3 800 million m^3 are in the productive forest. This represents an average growing stock of about 73 m^3/ha, but wide ranges of stocking density exist depending on local conditions. Some 25 m^3/ha are reported in the semi-arid forest of Radjasthan, while volume densities of around 200 m^3/ha are found in some temperate and sub-tropical forests. The coniferous forests account for almost 900 million m^3 with densities per ha ranging from 60 m^3/ha in Nepal to 275 m^3/ha in Bhutan.

This sub-continent also has a high proportion of managed forest, on average about 70 per cent but over 75 per cent in India which explains the high degree of utilization of the forests. In the managed forests the allowable annual cut is around 1 m^3/ha of industrial roundwood.

Despite efforts by the government authorities, about 11 million ha of forest is estimated to be under shifting cultivation, representing a loss of forest capital. On the other hand, this sub-region has a remarkable record with regard to plantations. In total 2.5 million ha have been established, 770 000 ha of this during the last five years. Historical records exist of teak plantations in India since 1840 in Nilambur. In the following years, planting remained sporadic until the mid-twentieth century when it gradually developed into a planned forestry rural development effort.

Continental South-East Asia

The continental South-East Asian sub-region, with a population of 185 million, has a forest area of some 66 million ha of tropical forest, of which about 41 million are considered productive, with 3.5 million ha under management.

It is an area of typical evergreen tropical forest with semi-deciduous evergreens in some areas. The forest in Burma and Kampuchea represents about 40 to 50 per cent of the total land area, while in Thailand the proportion is only 18 per cent. The coniferous forest covers about 750 000 ha divided between four countries but is practically absent in Kampuchea. The mangrove forest in Burma and Thailand amounts to some 1.1 million ha.

Part of this forest area is tropical mountain forest rising in parts to 2 000 m, with the temperature averaging around 27°C and annual rainfall between 1.8 and 3.0 m. Some dry deciduous forests are to be found in the lowlands, where rainfall is lower and there are pronounced dry seasons. Teak is prevalent in these areas.

Total growing stock in the closed forest is estimated at some 8 800 million m^3, of which 6 650 million m^3 are in the forests considered productive. This gives an average growing stock of some 160 m^3/ha. It is lower in Thailand, but around 180 m^3/ha in Burma, and still higher in Kampuchea and Laos.

The managed forests, mainly of teak and some mixed dipterocarp, have an "annual allowable cut" of 0.6 m^3/ha.

As to depreciation of the forest, cyclones have their effect, shifting cultivation destroys about 550 000 ha annually and bombing during the Vietnam war is reported to have damaged some 4 million ha of forest.

On the other hand, the plantation programme is steadily growing in importance. The total area of plantations in 1980 reached 350 000 ha, of which 180 000 ha was established during the previous five years; it includes 70 000 ha of coniferous plantations in Vietnam.

Insular South-East Asia

This sub-region, comprised of a string of islands strung out in the Pacific, has Asia's most important forest resources both in volume and in quality. It has a population of about 220 million.

The forest is mainly tropical evergreens with some semi-deciduous species. There is a prominence of trees of the dipterocarp family with Dipterocarpus, Shorea, and Parashorea species being the best known. The dipterocarp family constitutes up to 50 per cent of the dominant trees, and as they are tall and have well-known and similar technical characteristics, they constitute a highly valuable forest capital. This predominance prevails in the western parts of the area, but the dipterocarps no longer occur in East Indonesia. In the sub-region generally, the occurence of easily exploited peat swamp forest with dipterocarps present, should also be mentioned, as well as the mangrove forests in Indonesia, Malaysia and the Philippines.

In total the area of closed forest in this sub-region is estimated at some 148 million ha, which represents more than 55 per cent of the total land area. More than three-quarters of the forest is in Indonesia, especially in Kalimantan, Sumatra and Irian Jaya. The coniferous forests cover some 500 000 ha, mainly in Indonesia and the Philippines. Approximately 111 million ha of forest are considered operable.

Total growing stock is estimated at some 31 500 million m^3, of which some 21 000 million are in the productive forest with an average growing stock of about 200 m^3/ha, but average volumes per ha in undisturbed closed forest range from 265 m^3/ha in Indonesia to 300 m^3/ha in the Philippines. The annual allowable cut in some dipterocarp forest is estimated to be from 1.5 to 2.2 m^3/ha for most of the managed forest which covers some 2.5 million ha.

Annual disappearance of forest is estimated at about 1 million ha, mainly due to shifting cultivation and land-use reallocation, but on the other hand there is strong emphasis on plantation development. In total this is estimated at some 2.25 million ha, mainly in Indonesia and the Philippines, and has reached an annual rate of nearly 250 000 ha, 40 per cent of which are coniferous species.

1.1.4 The evolution of the resource

In the preceding part of this section an evaluation of the forest resource situation has been presented. In this part two of the major factors which affect the forest resources in the developing countries are described; deforestation and degradation on the one hand and reforestation on the other.

Deforestation

This review of deforestation is limited to its impact on the forest resources of the tropical developing world, as the previously mentioned FAO/UNEP study did not include non-tropical developing countries. That study distinguished between deforestation and degradation - the former being when the forest cover disappears and the latter being when the forest itself undergoes a reduction in the quantity and quality of the growing stock.

Table 1.6 shows the annual rate of deforestation expected between 1981 and 1985. Each year some 7.5 million ha of closed tropical forest are likely to disappear, of which 6.1 million ha are expected to be productive forest. Half of these productive forest losses are likely to occur in tropical America, 1.2 million ha in tropical Africa and 1.7 million in tropical Asia. This represents for all three continents a rate of deforestation of about 0.6 per cent per year.

Table 1.6 Expected annual deforestation in tropical forests: 1981-1985

million ha

Region	in productive closed forest	in all closed forest	in all tree formations
Tropical America	3.17	4.34	5.61
Tropical Africa	1.25	1.33	3.68
Tropical Asia	1.67	1.83	2.02
Total	6.09	7.50	11.31

Beyond the annual loss of some 7.5 million ha of closed forest, deforestation also has a serious impact on the other "open wood areas". The annual rate is estimated at about 3.8 million ha, of which some 2.3 million ha are in Africa. Though this disappearance of open wooded land does not directly affect the industrial wood potential, it is a severe loss of the production potential for fuelwood and building poles, as well as a further step in the savannisation and sometimes desertification of the rural areas.

The major cause of deforestation is spontaneous shifting agriculture where people simply need land to grow food crops. This is considered to be responsible for about 35 per cent of total deforestation in tropical America, 70 per cent in Africa and 50 per cent in tropical Asia. It is generally most acute where population pressure is highest and/or soils are poor, but next to agriculture, conversion of the forest land-use to extensive grazing is also important, especially in tropical America. Properly planned transfers of forest land for resettlement and agricultural developments account for only a small proportion of the total deforestation. The largest deforestation is going on in Brazil with 1.36 million ha annually, but this is still only some 0.5 per cent of all its forest. This rate is, however, particularly high for the Araucaria (Parana pine) forest in the southern part of the country. Rates of deforestation in Mexico and Colombia are higher than 1 per cent and range from 2 to 5 per cent in some other countries such as Costa Rica, Ecuador and Paraguay.

In tropical Africa, more than 700 000 ha of closed forest are destroyed annually in West Africa, 300 000 ha in Nigeria and the same in the Ivory Coast making a 4 per cent annual rate of clearing of closed forest in West Africa. The rate of clearing in East Africa is close to 1 per cent and reaches 1.5 per cent in Madagascar. The deforestation rates for the productive closed forests are even higher - 6 per cent in West Africa, 1.2 per cent in East Africa and 2.2 per cent in Madagascar. What is equally serious, however, is the state of the "open forest and other wooded areas" around the Central and West African forests, where these wood resources contribute substantially to the fuelwood supply, even beyond their productive capacity. This situation combined with the bush fires often leads to savannisation.

In tropical Asia, the annual deforestation is largest in insular South-East Asia (950 000 ha or 1.4 per cent). In Indonesia, deforestation is estimated at 600 000 ha per year while rates of 250 000 ha are reported for both Thailand and Malaysia; for other countries rates of 1 per cent are mentioned. In several countries, because of population pressure, farmers are forced up into the wooded uphill areas. Organized resettlement plans are important in this region and have to be mentioned. These relate to palm oil and rubber plantations in Malaysia, and agricultural settlement schemes in Indonesia, Sri Lanka and Nepal.

Degradation

Finally, as the FAO/UNEP study points out, next to deforestation, losses occur through degradation of the closed forest formations. It is a process where progressive changes occur separately or concurrently which result in a qualitative and quantitative reduction of the growing stock, with changes and often a reduction in its production potential. The main causes of this are logging, exploitation for fuelwood and other roundwood, grazing and fires.

Logging is undertaken annually in some 4 million ha of tropical productive forest. Where this occurs within the framework of a management plan, the resulting extraction should be within the recuperative biological and sylvicultural capacity of the forest stand. Management plans are prevalent in some countries in Asia, but are rather the exception elsewhere. The absence of plans results in an effective degradation of the forest under exploitation, and logging, if badly practised, can also increase the damage to the stand.

Exploitation for fuelwood and other wood in the round can cause degradation if the removals exceed the yield of the forest. This may lead to degradation of the forest cover as typically occurs around the urban centers and in rural areas with high population density.

Overgrazing can also cause degradation, especially if shepherds light fires to start the herbaceous regrowth and fires are known to be a main cause of degradation resulting in a gradual savannisation both of "closed forest" and of "open woodlands".

Plantations

Plantations have long been the forester's answer to deforestation and as such they have been used as a means of assisting or replacing natural regeneration. In the developed world, the plantation has become a standard tool for the forester to maintain or improve the productive capacity of his forest resource and even to create a new one. In Europe, the extension of the forest area through plantations has reached a total of 300 000 ha since the second world war.

Similarly, in the developing countries, a big reforestation effort is noticeable since 1950. Among the developing countries of the temperate zone, China, without doubt, has accomplished the most impressive reforestation programme, reportedly covering some 30 million ha. Two-thirds of this are for timber production, 6 per cent for protection, 13 per cent bamboo plantations and the rest are "other" (fruit) tree plantations. In order to meet the prospective demands for timber and other forest products, the afforestation effort in that country is supposed to cover an area of 70 million ha by the year 2000.

In the developing countries of the tropical zone, according to the FAO/UNEP study, the total area of plantations existing in 1980, as given in Table 1.7, is about 11.5 million ha, of which some 26 per cent are coniferous species, 47 per cent fast growing hardwood species and 27 per cent other broad-leaved species.

On a regional basis, Tropical America, Africa and Asia account respectively for 40, 15 and 45 per cent of the total plantations. The fact that 40 per cent of all these plantations were established over the years 1976-1980 illustrates the tremendous increase of this afforestation effort in recent years, and existing plans for the future do not seem to show any noticeable change downward. The present planned annual rates of afforestation, again for tropical America, Africa and Asia respectively, are 535 000 ha, 126 000 ha and 438 000 ha, or an annual total of some 1 100 000 ha.

Table 1.7 Established plantations in tropical developing countries in 1980
1 000 ha

Region	INDUSTRIAL PLANTATIONS				All plantations
	broadleaved		coniferous	total	(industrial and non-industrial)
	fast growing	other			
Tropical America	868	129	1 571	2 568	4 620
Tropical Africa	162	294	541	997	1 780
Tropical Asia	1 083	1 813	606	3 502	5 111
Total	2 113	2 236	2 718	7 067	11 511

A breakdown of this plantation programme is necessary with regard to its objectives. Some 61 per cent of all plantations are reportedly "industrial plantations", i.e. plantations for the production of industrial type roundwood; the other 39 per cent being mainly fuelwood plantations established to supply the energy needs of the population at the household level. The increasing rate of formation has been particularly strong for the non-industrial plantations as the energy gap for the population in the developing world is still widening.

As to the "industrial" plantations themselves, by 1980 some 7.1 million ha had been established, of which 4.35 million ha were hardwood species and almost half of these again were fast growing species. The planned annual rate of formation of these plantations in the tropical developing world is around 580 000 ha of which 49 per cent is in tropical America, almost 40 per cent in tropical Asia and only 11 per cent in tropical Africa. This represents a 20 per cent increase over the annual rate of planting in the past five years.

Table 1.8 Planned annual rate of formation of plantations in tropical developing countries: 1981-1985

1 000 ha

Region	INDUSTRIAL PLANTATIONS			All plantations (industrial and non-industrial)
	Hardwood	Softwood	Total	
Tropical America	116	167	283	535
Tropical Africa	38	26	64	126
Tropical Asia	160	73	233	438
Total	314	266	580	1 099

More than 77 per cent of the industrial plantations in tropical America are concentrated in Brazil, where the plantation area has reached the impressive total of 2 million ha, with Eucalyptus, Pinus and Gonelina as the most frequently used species. This is without taking into account the plantations for charcoal for the iron industry. Cuba, Venezuela, Colombia and Mexico also have large industrial plantations totalling some 450 000 ha.

In tropical Africa, industrial plantations reached almost 1 million ha in 1980. 350 000 ha of the industrial hardwood plantations here were established over the last 20 years. Nigeria, Angola, Ivory Coast, Sudan and Ghana accounted for 270 000 ha of them. The industrial softwood plantations reached 540 000 ha, located mainly in Madagascar, Kenya, Malawi, Tanzania and Zimbabwe. Formation of non-industrial plantations reached an annual rate of about 40 000 ha by 1980 and is to be increased to 64 000 ha a year thereafter.

In tropical Asia by 1980, industrial plantations covered a total area of 3.5 million ha, of which India and Indonesia together accounted for about 85 per cent. The annual rate of formation of these plantations is now 233 000 ha, of which about 110 000 ha are in Indonesia and 85 000 ha in India. However, Bangladesh, Sri Lanka, the Philippines and Vietnam already have industrial plantation programmes nearing 10 000 ha per year. In tropical Asia, coniferous species accounted for some 17 per cent of all established industrial plantations, though in recent years they have accounted for more than 27 per cent of the new plantations in the region generally, and almost 50 per cent and 80 per cent in Indonesia and Vietnam respectively. With regard to the slower growing hardwood species, teak (Tectona grandis) is by far the most important, while among the fast growing hardwood species Eucalyptus predominates. For the industrial softwood plantations, several pines have been used successfully. Formation of non-industrial plantations in tropical Asia had reached an annual rate of 177 000 ha by 1980.

It is not simple to assess the impact of the plantation programmes in the developing countries on the overall production potential of their forest resources. Growth rates vary widely according to species, terrain and bio-climatic conditions. but generally these growth rates are high compared with those of the natural forest. Once established, and of age, their potential contribution to forest industry development is high. It is estimated that they already contribute 40 per cent of the industrial roundwood production in tropical America and 5 per cent in Africa and Asia. Their production of fuelwood and building poles is also substantial, though it has not been separately assessed.

It is clear that this fast increasing programme for formation of industrial plantation will have a positive effect or the authorities would not proceed to these plantations. But it should be remembered that this world-wide plantation establishment effort of 1 million ha of industrial and non-industrial plantations per year in tropical .. should be compared with the annual deforestation of over 7 million ha of closed forest in these countries, to which should be added the 4 million ha of annual degradation of these forests. The annual rates of plantation establishment can be compared to those of deforestation and give a comparative plantation/deforestation ratio which one could call a "replacement ratio". This ratio, if applied to the closed forest, is 1:8 in tropical America including Brazil, but only 1:33 when excluding Brazil, 1:11 in tropical Africa and 1:4 in tropical Asia. In fact, this reforestation effort is a direct response by the national authorities to the prospective future needs and shortages of wood and forest products.

The situation in the tropical developing countries, however, seems to be one where a vast wood industry development potential lies unutilized or underutilized in the tropical forest, while the same forest is in danger of being sacrificed to other uses and other needs of society, often because of this underutilization.

1.2 Use of forest resources

1.2.1 Present use of the forest resources

The resource situation

In order to give a brief assessment of the degree of industrial utilization of the world forest resources, this summary review compares the distribution of these resources with their present use for industrial purposes.

Table 1.9 presents the geographic distribution of the world's forest resources. In line with the objective of this paper it only provides data on the closed operable forest, giving forest areas, standing volumes, and population data.

Table 1.9 Distribution of forest resources by development region

	Population	Operable forest		
		Area	Volume in 1 000 million m^3	
	millions	million ha	Total	Coniferous
Developed	1 164	940	96	72
Developing temperate	1 189	150	12	..
Developing tropical	2 062	885	162	2
Total Developing	3 251	1 035	174	..
Total World	4 415	1 975	270	..

The Developed World

As this table indicates, the developed world, with 42 per cent of the world's land area but with only 26 per cent of the world's population, possesses 48 per cent of the world's area of operable forest, but only 37 per cent of the total growing stock in these forest. As to the species composition of this growing stock, it consists roughly of 75 per cent of coniferous species and 25 per cent of broad-leaved species.

These forest resources in the operable forest, total about 96 000 million m^3 over an area of 940 million ha, which gives an average growing stock of slightly over 100 m^3/ha. As they have to serve about 1 160 million people, that means per capita about 0.8 ha of operable forest and 83 m^3 of standing timber. Of course, with population density more than eight times higher in Europe (102 inhabitants/km^2) than in North America and the USSR (12 inhabitants per km^2), the availability of both forest area and standing volume is about five times higher there than in Europe which has only 29 m^3 of standing timber and roughly 0.27 ha of operable forest per capita.

The Developing world

As to the developing world, it has 58 per cent of the world's land area, but 74 per cent of the world's population. In terms of forest resources, it has 52 per cent of the world's operable forest areas, but 63 per cent of the wood volume in these forests.

Temperate zone

It is useful, however, in terms of this analysis, to assess separately the situation in the developing countries in the temperate zone. This includes, Argentina, Chile, and Uruguay in South America, all the countries in the Near East and West Asia, plus China, Mongolia and the two Koreas. These countries which contain almost one-third of the world's population, only have 8 per cent of the world's forest area and 5 per cent of the wood volume of these forest. Total growing stock is estimated at some 12 700 million m^3 or about 9 m^3 per capita and the available forest area at only slightly more than 0.1 ha per capita. Coniferous species represent between 50 and 60 per cent of these forests.

Tropical Zone

In the developing countries in the non-temperate climate zone, a growing stock of some 162 000 million m^3 is available over an area of about 885 million ha of forest with 183 m^3 of standing timber per ha, but this has to serve 2062 million people or 46 per cent of the world's population. This is mainly broadleaved coniferous species representing only some 1.5 per cent. Latin America has more than half of this growing stock (53 per cent) for only 17 per cent of the population in the tropical developing countries. Africa has 25 per cent of the growing stock for about 17 per cent of the population, while the remaining part of Asia, with 65 per cent of that population has a growing stock of some 32 billion m^3, or 20 per cent of that of the tropical developing countries.

In the developing countries in the non-temperate climate zone, a growing stock of some 162 000 million m^3 is available over an area of about 885 million ha of forest with 183 m^3 of standing timber per ha, but this has to serve 2 062 million people or 46 per cent of the world's population. This is mainly broad leaved coniferous species representing only some 1.5 per cent. Latin America has more than half of this growing stock (53 per cent) for only 17 per cent of the population in the tropical developing countries. Africa has 25 per cent of the growing stock for about 17 per cent of the population, while the remaining part of Asia, with 65 per cent of that population, has a growing stock of some 32 million m^3, or 20 per cent of that of the tropical developing countries.

Utilization in 1980

The following review of the utilization of the world's productive forest resources indicates that scant utilization is made of these in the tropical developing countries for production of industrial raw material. The review is based on the year 1980 when utilization was slightly below average because of the down turn in the world economy, but this probably influenced the intensity of industrial wood utilization rather than the pattern.

This presentation also considers utilization in terms of removal from the forest for a specific industrial purpose. Only an occasional reference is made in this section whether or not the industrial processing is done locally, as this aspect and the policy implications are covered in detail in Section 2.

Fuelwood accounted for 54 per cent of all roundwood production; but 90 per cent of this was in the developing world, where it represented the major and sometimes sole source of energy for over 2 billion people. This production of about 1 500 million m^3 of fuelwood also represented some 83 per cent of the total roundwood production in the developing countries. However, this is not a direct measure of utilization of the operable forest, as a substantial part of the fuelwood comes from "other forest and wooded lands" and even from outside the forest.

Table 1.10 Industrial roundwood production in tropical developing countries
(in million m^3)

	INDUSTRIAL ROUNDWOOD				
	Total	Of which coniferous	Sawlogs and veneer logs	Pulpwood	Other industrial roundwood
Tropical America	63	26	45	12	7
Tropical Africa	41	3	21	2	18
Tropical Asia	91	1	73	3	15
Total Tropical Developing	195	30	139	17	39

The world production of industrial roundwood, totalled 1 400 million m^3 in 1980, and almost 80 per cent was produced in the developed countries.

Of the 1 100 million m^3 produced in the developed world, 42 per cent came from North America, 26 per cent from Europe, 25 per cent from the USSR and some 6 per cent from the "other" countries. On average 79 per cent of this production was from coniferous species, but this ranged from 73 per cent in Europe to [illegible] per cent in the USSR. The North American production accounted for one-third of the world's production while Europe and the USSR each produced one-fifth.

In the developing world, 294 million m^3 of industrial roundwood were produced, one-third by countries in the temperate zone and two-thirds by those in the tropical zone, though the volume relationship between their respective growing stock is one to twelve.

In order to analyze the degree of utilization of the different forest types in the developing world, it is necessary to consider separately the use of the coniferous species in the temperate and tropical zones of the developing world.

Table 1.11 Roundwood production 1980 by development region (in million m^3)

Region	Total	Fuelwood	INDUSTRIAL ROUNDWOOD: Total	Of which coniferous	Saw logs and veneer logs	Pulpwood	Other industrial roundwood
Developed	1 251	151	1 100	872	651	312	137
Developing temperate	364	265	99	65	52	12	35
Developing tropical	1 406	1 211	195	30	139	17	39
Total developing	1 770	1 476	294	95	191	29	75
Total World	3 021	1 627	1 394	967	842	341	212

In the developing countries of the temperate zone, production of coniferous species reached 65 million m^3, which represented 65 per cent of their output of industrial roundwood. Precise data about the volume composition of their growing stock is not available, but conifers are estimated to be 50 and 60 per cent of the total.

In the developing countries of the tropical zone the production of industrial wood from coniferous species reached about 32 million m^3, or 16 per cent of their total industrial production. However, as 27 million m^3 of these conifers came mainly from the Parana pine forests in Brazil and Mexico, and it is somewhat artifical to classify these as belonging to the tropical zone, that production is recorded here for reference but is excluded from the following utilization analysis of the tropical forest resources. As the foregoing figures include production from plantation as well as from natural forest, this again stresses the low intensity of industrial use of the tropical forest.

A breakdown of the 1980 production of 294 million m^3 of industrial roundwood in developing countries indicates that this comprised 190 million m^3 of sawlog and veneer logs, and 28 million m^3 of pulpwood used by forest industries, plus 75 million m^3 of wood for non-industrial use in the round as poles, piling and posts. In the developing countries this last category is used extensively for building. In China, it represents almost 40 per cent of the total industrial roundwood production. In the other developing countries, at least in those with forest, it is probably of similar importance. Statistical data put 20 per cent of total industrial roundwood production in this category, but much of this type of product is often not recorded. Moreover, such poles are also harvested outside the forest.

The analysis now examines the quantities of industrial roundwood effectively produced for industrial processing.

The broad picture for 1980, as given in Tables 1.10 and 1.11, shows that some 52 million m^3 of sawlogs and veneer logs were produced in the temperate forests of the developing world - 36 million m^3 of this in China - and some 139 million m^3 in the tropical developing world. Of the tropical production, 45 million m^3 were produced in Latin America, 21 million m^3 in Africa and 73 million m^3 in Asia.

Latin America, with 53 per cent of the world's tropical forest resources, produced only one-third of the production of tropical sawlogs. However, the picture is distorted by the forest utilization in Brazil, which concentrates on limited coniferous forest resources near to main markets in the South, rather than on the practically unlimited tropical forest resources of the Amazon that are far away from the local markets. This situation may well change in the future because the pine forest in the South is being exploited far beyond its sustainable capacity level. Most of the other Latin American countries, in fact, have a rate of exploitation at least equal to the world's average for the tropical forest.

The use of the forest resources in Africa suffers from a similar type of distortion. More than half of its total growing stock is concentrated in Zaire, where 20 000 million m^3 of tropical forest produced only some

300 000 m^3 of sawlog and veneer logs. The utilization of these tremendous forest resources may well have to wait until the transport problem on the Zaire river is solved. In general, the other central and west African countries reached a level of utilization above the rate of depletion. This may, however, be part of an overall land-use policy, rather than a long-term forest development policy, or lack of it.

Asia, in general, had a better record in terms of the overall utilization of its tropical forest resources. Though it has 21 per cent of the world's resources of tropical forest, it accounted for more than half of its production of sawlog and veneer logs. This situation may be a fortunate or fortuitous concurrence of circumstances, but it shows that, despite the technical difficulties and circumstances involved, these tropical forest resources can make a substantial contribution to forest industry development.

In the countries of Central South Asias, from Pakistan to Bangladesh, 5.5 million m^3 of sawlogs were produced from a growing stock of 3 850 million m^3, a rate of utilization 50 per cent higher than the world's average for tropical forest resources. Though part of these resources can also be labelled sub-tropical or temperate forests, the presence of a huge market rather close to the forest and a high level of forest management (India has 75 per cent of its operable forest under management) explains much of these positive results.

In the countries in continental South East Asia, from Burma to Vietnam, the utilization record is about average, but can be expected to increase substantially as there is a huge local market potential and high quality forests which are largely of Dipterocarp species. The rate of utilization in Thailand is very high, but for the countries of the Indo-China Peninsula, post-war development efforts may bring a high level of utilization, 4 million ha of forest are reported to have incurred bomb damage.

In the countries of insular South East Asia, including Malaysia, the Philippines, Indonesia and New Guinea, the contribution of the forest resources to industrial development has grown over the last two decades to an impressive level. This region, with 14 per cent of the world's tropical forest resources, produced 50 per cent of the world's production of tropical sawlogs in 1980. Certainly, conditions are favourable with the presence, at least in the Western part of this vast region, of the rather homogeneous Dipterocarp forest and important local and export markets that absorbed some 31 million m^3 of logs. Almost 50 per cent of the logs produced were exported. These countries have developed a policy over the last decade of increased local processing of logs and this policy is expected to be vigorously pursued by the countries concerned. The Philippines have practically stopped their log exports, and in Indonesia it has recently been sharply cut back. This increased local processing, if coupled with long-term forest development and management plans, can steadily increase the contribution of the forest to local development.

Pulpwood production in the developing countries totalled 28 million m^3, 11 million coming from the temperate regions and 17 million from the tropical regions. However, even in the tropical regions this largely came from plantations which are nearly 60 per cent conifer species. Although they are a productive use of the forest resources, they cannot be considered as production from the tropical broad-leaved forest.

The total amount of industrial roundwood used in the tropical developing countries was 115 million m^3 of sawlogs and veneer logs and somewhat over 16 million m^3 of pulpwood. In addition they had exports to the developed world of some 25 million m^3 of sawlog and veneer logs and of some 0.5 million m^3 of pulpwood chips.

The Degree of utilization

The degree of utilization can be expressed in different ways. One method is to compare the production per ha with the allowable annual cut. Another is to calculate the roundwood production as a ratio of the volume of the growing stock. Both calculations provide only a broad indication of productivity, particularly as some of the production comes from plantations for which age distribution is important as well as growing stock data. Nevertheless, both can be used as an indicative tool to provide a general evaluation of productivity.

The following analysis underlines the difference in levels of utilization of the forest between countries in the developed and developing world . As previously mentioned a distinction is made for the developing world between forest utilization in the temperate and tropical forests.

Table 1.12 compares the production of industrial wood with the resources available in the developed and developing world.

Table 1.12 Comparison of population, forest resources and roundwood production as percentage of world

	Population	Growing stock	Total roundwood production	Industrial roundwood production	Sawlogs and veneer logs	Pulpwood
	%	%	%	%	%	%
Developed	26	37	41	79	77	92
Developing temperate	32	5	12	7	6	3
Developing tropical	41	58	47	14	17	5
Developing total	74	63	59	21	23	8
World total	100	100	100	100	100	100

The developed world, with 37 per cent of the world's growing stock, produces 1 100 million m^3 or 79 per cent of the industrial wood; 652 million m^3 as sawlogs and veneer logs, 312 million m^3 as pulpwood and some 137 million m^3 of other industrial roundwood, comprising poles, piling, posts and pitprops. The production of sawlogs and veneer logs, and of pulpwood represents respectively 77 and 91 per cent of the world's production of those categories.

The overall production represents an output of 1.2 m^3 per ha of operable forest, compared to an annual increment of 1.7 m^3/ha. In Europe, where both utilization and management are most intense, production is at about

2.05 m^3/ha while annual growth is about 3.3 m^3/ha. The least intensive use in volume terms per ha is is the USSR with a production of 0.7 m^3/ha and an annual growth of 1.2 m^3/ha. Production figures in m^3 per 1 000 m^3 of growing stock reached 12 m^2 for the whole developed region, with 20 m^3 for Europe, 12 m^3 for North America and 7 m^3 for the USSR. On this basis, the present rate of utilization in the developed world is still significantly below the annual increment.

The developing temperate region, with about 5 per cent of the world's forest resources, produces 99 million m^3 or some 7 per cent of the world industrial roundwood, some 6 per cent of the sawlog and veneer logs and 3 per cent of the pulpwood. But it should be remembered that this is to serve 32 per cent of the world's population. In terms of utilization of the forest resources this is about 0.7 m^3/ha and 7.5 m^3 per 1 000 m^3 of growing stock, both similar to the ratios obtained in the USSR. But this comparison has only some meaning when one takes into account the huge differences in population density.

The developing countries in the tropical zone, with 54 per cent of the world's growing stock, and 40 per cent of the world's population, produce 195 million m^3 or 14 per cent of the world's production of industrial wood, 17 per cent of the sawlogs and veneer logs and 5 per cent of the pulpwood. The total production figure of 130 million m^3 of sawlogs and veneer logs, after abstracting the 15 million m^3 coming from coniferous species, gives a production figure of roughly 0.25 m^3/ha, or a productivity in the tropical broad-leaved forest of slightly less than 1 m^3 per 1 000 m^3 of growing stock.

1.2.2 Factors determining the use of wood

This section so far has presented a broad review of the world's forest resource potential, as well as its use for industrial development. It emerges that the forest in many countries in the tropical developing world is only utilized to a low degree for industrial purposes. This section continues with an examination of reasons for this situation, analysing first, the technical and economic factors which contribute to this, and then the institutional aspects.

Technical and economic conditions

The use of wood is determined on the basis of its technical characteristics and by a combination of economic and industrial criteria dominated by consumer requirements. This review covers the use of wood in general and by the timber industry with specific attention to the conditions prevailing in the developing countries.

Wood for energy

Wood can be used simply for its energy value. In fact, that is its major use in the world, especially in the developing countries. This use disregards both the structural qualities or the fibre qualities of the wood and is entirely and solely based on the caloric value. However, for about 2000 million people in the developing world, it is the major means of meeting their essential energy needs, most of which are simply the daily household needs of preparing food and drink, some heating and some artisanal uses. In the rural economy in particular it is also an essential input for a large set of productive activities that lead to some economic development in the low-income conditions.

The growing of wood for direct or indirect production of energy on an industrial scale does exist in various parts of the world and even more so in the developing countries where fuelwood is used for a series of industrial activities. This includes, on different scales, brick factories, potteries, mineral extraction, tobacco curing, and various activities based on drying, preserving and preparing food and drink under any form.

Attention should also be drawn to some other uses of wood as an energy input in the mechanical wood-processing industries. This is certainly not new, as the amount of wood residues in wood-working industries can be substantial. Since the energy crisis of the seventies, with its important shifts in the relative costs of energy, increasing attention has been given to the use of such residues for heat and power. In the industrialized world, significant changes have occured and some of the big wood-based concerns are becoming energy self-sufficient. This trend in the wood industry is only the expression of a search for a new energy economy. The result will inevitably increase the use of industrial wood residues as an energy input. As yet little of this thinking has percolated into the developing countries' wood industries. Attention may have to be given to the formulation of an appropriate energy technology that could be applied to small-scale industries, as well as to the institutional framework to allow this activity where economically feasible.

Finally, the feasibility of producing wood simply for its energy equivalence certainly begs further scrutiny from the technical, economic and social points of view. In the developing world, large development programmes for "non-industrial" plantations are being undertaken and gradually expanded to serve the fuelwood needs of the sprawling urban centres, which often have a large component of low income inhabitants. However, at least one country has gone further and is creating plantations for the production of electricity. Experience will show whether, in view of the prospective evolution of energy prices in real terms, a viable wood-based energy producing industrial activity is feasible, and under which conditions it could evolve. Such an experiment may well indicate the way to analyse and develop this forest industry potential.

Wood for rural consumption

In the rural economy wood is often used in the round. This has been decreasing gradually in the developed world but this use remains of high importance in the developing countries, especially in rural areas, where wooden building poles are a traditional material for construction of housing, fencing and scaffolding. Its use does not necessarily enter the monetary economy, but in the developing countries the contribution of roundwood to the living conditions of the population is substantial.

As economies develop, wood in the round tends to be replaced either by sawnwood or by non-wood materials. As an example, the use of sawnwood rafters to support tin roofs has expanded enormously since the availability of modern roofing materials a development that will probably continue to increase rapidly. Treatment or seasoning of the wood would certainly increase its appeal and use.

Wood is also used to a large extent in the wooded developing countries to provide an enormous variety of tools and equipment, both inside and outside the monetary economy. In several of the wood rich developing countries this has even developed into an export industry with substantial economic and social returns. Here again the scope for expansion in this industry is substantial.

The wood-processing industries

The mechanical wood-processing industries use the wood for its structural characteristics. The technical characteristics of the wood will determine the destination of the wood as an end-product. How then is wood used in general? Examples are taken from the use patterns in the temperate world simply because user data is not available for the tropical zone countries but reference is made to the additional wood characteristics required by climatic conditions in such countries.

In the developed countries during the nineteen seventies, construction accounted for roughly 60 per cent of all sawnwood used and 50 per cent of all wood-based panels. Of this, about 49 per cent was used for housing, including new buildings, repair and maintenance. In residential construction the use of wood is more intensive in low-rise than in high-rise building. The use of wood, sawnwood and wood-based panels, is also important in non-residential building such as schools, offices, courts, theatres, halls, farm buildings, holiday chalets and huts for temporary engineering projects. The use of wood-based panels in this way is steadily increasing and already accounts in volume terms for more than 20 per cent of all wood used.

The second largest use of wood is for packaging, as crates, cases and pallets have become increasingly important because of mechanical handling. In this sector, substitution of other materials is occurring, but wood still remains popular for many traditional uses where ease of working and light weight, rather than durability, is important.

Finally, the furniture industry is the third largest consumer of sawnwood and wood-based panels, using these in a wide range of products that are made in plants ranging from the highly mechanized to the small artisan enterprises. Substitution of non-wood materials has occurred but it remains an industry where consumer preference is dominant and wood as a "natural" material maintains its appeal.

On the basis of these broad use categories, it is possible to give only some very general sets of requirements, as quite specific combinations of technical characteristics prevail for each particular use.

Wood used for structural purposes requires a combination of strength, size and weight; for joinery, workability, stability and resilience are important; for furniture making, appearance, workability, possibility of finishing and acceptance of paints predominate; finally, for packaging, cheapness, resilience and light weight are important.

With wood-based panels, the same criteria apply for the particular use category. But for wood for veneer, plywood, particleboard and fibreboard, some additional technical characteristics should be mentioned, such as the possibility of slicing or peeling, the possibility of glueing, strength and dimensional stability and acceptance of paints and varnishes.

For the tropical regions, these same requirements apply, plus durability against fungal and insect attack as well as stability in environments with fluctuating humidity.

The wide variety of required charcteristics do not exclude the tropical hardwood species, or put them at a disadvantage; on the contrary, some of them are highly appreciated as fine timbers for furniture and decorative uses, and their high density is a requirement in some uses. But the handicap the wood industry is facing in the tropical forest, with its high species mix of trees with highly different technological characteristics, can only be overcome by methods involving higher per unit operational costs. As previously indicated, the use of wood by forest industries is determined by the wood's technical characteristics, together with the technical and economic feasibility of converting this to products for the price society is willing and able to pay for them.

Historically, the development of the wood industries in the early 20th century was largely due to the technical characteristics of the coniferous species which produce a light, regular raw material, rather simple to work and which was, moreover, available in large homogeneous quantities. Even now, towards the end of the 20th century, industry still uses more conifer than broad-leaved species, both in the developed and the developing world.

It may be that this larger availability of coniferous species has influenced consumers' tastes and requirements, and that the technology developed by the wood industry in the developed world has always been influenced by the greater availability of coniferous species in the industrialized world. In any case, entry of the wood industry into the tropical forest required a technology adapted to a wide variety of different hardwood species. This "appropriate technology" problem is dealt with in the next chapter, but reference to it here is necessary to illustrate the technical problems facing the use of the tropical forest in the developing world.

It is also necessary to draw attention to the economic problems of logging and transport in the tropical forest because of the high species mix. This economic problem is covered in detail in the section on logging and transport as it is a major constraint on the development of the forest industries in these tropical forests. Where the species mix is less heterogeneous, as in the dipterocarp forest of South-East Asia, the utilization of the forest resources is now three times the level of Africa and Latin America in terms of industrial wood produced per 1 000 m^3 of growing stock of closed productive forest, but is still four times lower than in the developed world. Equally interesting is the fact that wherever coniferous stands are found in the forests of the developing world, they are used intensively such as the Parana pine forests in Brazil and the pine forest in Central America. Certainly it is worth noting that even in the developed world the forest industries use the coniferous forest 20 to 30 per cent more intensively than the broad-leaved forests, a trend which is found in all the industrialized regions under review. The possible implications for the development of the forest industrial technology should not be overlooked.

Broadly speaking, the mechanical wood industry is a low to medium capital intensive industry, with capital requirements high for the logging and transport industry; low for the sawnwood industry; and medium for the wood-based panel industry. As to labour input, it can be considered of medium intensity in all the three sub-sectors. Applying labour in wood manufacturing enhances the value of the product. The mechanical wood industries thus provide both a value added product and employment. With high wood and labour costs in the developed world, a transfer of an increasing portion of the production of wood product to the developing countries can be expected on economic grounds, because of the much lower labour costs in the developing countries. This trend is in progress, influenced both by government policies and by economic pressure.

Still in 1980, 16 per cent of the sawlogs and veneer logs produced in the developing countries were exported to developed countries, as against 10 per cent for sawnwood similarly exported.

The pulp and paper manufacture industries

The use of wood by the pulp and paper industries is largely determined by the quality of the fibre. Among the important characteristics are fibre length and fibre flexibility. Thus, pulpwood is generally any wood which does not meet the technical characteristics required for the mechanical wood industries, but has certain desirable fibre characteristics and does not contain components that make the pulp processing more difficult or costly.

A distinction to make here is that coniferous species have long fibres and broad-leaved species short fibres. The use of the two types of fibres by the pulp and paper industries depends on the type of paper to be produced, but a certain input of long fibre pulp is generally required.

Historically, as for the mechanical wood processing industries, the large-scale pulp and paper industry was developed in the northern belt of the temperate regions. It was based in its early stages, largely on the input of thinnings from coniferous stands, but with the industry's steady expansion, pulpwood from broad-leaved species gradually entered the scene.

The wood pulp industry in the industrialized world has evolved into a highly capitalised and technology-intensive industry, requiring large amounts of long-term capital investments, high energy and water inputs, and because of its steadily increasing scale, a large and regular availability of a uniform wood raw material. Though initially based on natural forest produce, plantations have long since entered the supply structure.

The development of this industry in the developing countries, scant as it is, has been largely determined by the raw material availability. Due to earlier research efforts, a technology has existed for some time which utilizes broad-leaved species for pulping and paper making. As a consequence of this and more specific research directed to utilization of the tremendous growth potential of bio-climatic conditions in the tropics, it is now technically possible to use a wide variety of tropical hardwood species, either individually or in an almost naturally occurring mixture, to manufacture pulp suitable for a mixture of grades of paper and paperboard. A complementary input of pulp from coniferous species is still necessary, however, especially if industrial grade paper is to be one of the end-products.

Although technological progress has opened possibilities for the use of tropical broad-leaved species for pulpwood, considerable sylvicultural problems remain to be solved. One of these problems is that the natural regrowth of a typically heterogeneous tropical forest does not necessarily have the same species/volume composition as the original tropical forest on which the pulp and paper processing technology will have been based. In fact, even the probable composition of that regrowth will be hardly known at all.

For that reason, conversion to plantations does offer an alternative and regular - though more expensive - raw material. Research on this subject may provide interesting answers.

Large-scale integrated wood and pulp producing concerns have often been envisaged in the developing world, but the size and complexity of these concerns have limited their success to particularly favourable conditions. Because of their scale, such undertakings generally require a set of specific infrastructural and institutional conditions.

The pulp and paper industry could gradually develop further to utilize the vast forest and forestry potential in the developing countries, both tropical and temperate. It is steadily increasing its use of both the natural forests and plantations and, with this raw material input structure, plantations of fast growing coniferous and broad-leaved species may offer interesting opportunities for faster industrial development of this sector.

The institutional, infrastructural and technical requirements that predetermine development of this industry in the tropics are complex and may well require considerable increased international attention and assistance.

The institutional aspects

It is important to review briefly the relationship between forest industries and forest resources in both the short and the long-term, especially with regard to the situation in the developing countries.

In the developed countries this relationship is dependent on providing an optimal set of returns to consumers, distributed over time. This is achieved by allocating to the forest industry complex the means and incentives to produce the set of products required by the society. In the centrally planned economies this is the responsibility of the state planning authorities. In the market economies this is or should be achieved by the interplay of market forces and the socio-economic claims of the various pressure groups.

Even though the procedures involved are distinctly different in the two systems, the overall development of the forest industries in each has not been significantly different. Both have resulted in a high degree of industrial utilization of the forest of between 7 and 20 m^3 of industrial wood produced per 1 000 m^3 of growing stock. In fact, the different ownership pattern involved does not seem to play a determinant role. But under both the market economy and the planned economy systems, the utilization of the forest resources has taken place under an institutional system of forest management of some kind. Moreover, in the three major regions under review - North America, Europe and the USSR - this had led to a utilization pattern where the prevailing rates of industrial roundwood production remain below the levels of "allowed annual cut" considered consistent with the long-term utilization objectives. This is the more important when, besides wood production, the forest in the developed world is called upon to provide a growing series of non-wood values and products which may, in the future, influence both the quantity of the wood available as well as its price.

If overall no causal relationship may exist between forest industry development and forest management, it has at least proved to be essential to institutionalize the relationship between the short-term claims of consumers to maximize their enjoyment of the forest products and the long-term interest of society. If the forester tends to claim that this link is esssential, he can submit that this institutional arrangement has worked out positively, at the very least, in the developed world with its temperate forest.

The situation in the developing world is quite different. As shown in the previous section of this chapter, forest management exists in only a few cases in the developing world, though with good results where this has been done.

In Latin America, managed forests constitute only 0.1 per cent of the operable forest and half of this is in one country, Nicaragua. In Africa, 0.6 per cent of the operable forest are reportedly under management but in practice it is largely inoperative. In Asia, management plans cover broadly 20 per cent of the operable forest in the market economy countries. This information is not readily available for the planned economy countries, but conceptually it should reach an even higher level. Moreover, the existence of forest management plans seems to follow closely the degree of industrial utilization of the forest. In South Asia, India has reached a level 50 per cent higher than the average for the developing countries and some further 6 million ha of forest are under management in Burma and in Malaysia (Sarawak) also with positive results.

If the forester rates the existence of forest management plans as essential, proof could be difficult to provide. He may, however, have less difficulty in submitting that the existence of a forestry industry-oriented development policy is essential for the optimal economic development of forest industries. To implement such a policy, government authorities in the developing countries needs an institutional structure, a department to supervise this development and to activate and control implementation, and a philosophy of long-term resource management rather than short-term exploitation.

A forest industry requires capital investment, which is an allocation of non-wood resources to the utilization and transformation of forest resources. These non-wood resources have to be paid for at least as well as in alternative uses. In the wood industry, the more capital-intensive the activity the larger will be the scale of production needed to pay for the capital input. The industry thus needs a time horizon over which all its requirements, including its wood raw material requirements, can be secured. This requires authorities which are institutionally and technically in a position to provide these guarantees. This requirement may well be one of the most serious constraints, next to the technical ones mentioned above, that hinder the development of the forest industries in the developing countries. This becomes even more so when the capital input, and/or the technological know-how have to be imported, as is often the case in the pulp and paper industry. Moreover, in the absence of a local market, the industry may initially be producing primarily for the export market, and may even for several reasons, including simplicity, continue to pay major attention to the export market. A policy directive may therefore be necessary, while safeguarding foreign capital interests with its essential claims for financial returns, to increase production for the local markets within a reasonable time horizon as well as provide adequate returns for the local inputs.

This will lead inevitably to an equally important corollary with regard to the returns to the local economy in general. In 1980, log exports of tropical developing countries were around 40 million m^3, of which about 25 million m^3 went to the developed countries. These exports of logs, with a unit value of about US$ 100 per m^3 in 1980, thus gave a handsome US$ 4 000 million foreign currency revenue. Exports of logs, however, also imply the export of employment as well as the added value which those products could obtain if manufactured locally. Several countries have already initiated a policy of favouring exports of manufactured wood products rather than of logs. Though implementation of such a policy may not be easy, it is a move towards the exports of more highly manufactured wood products which will need increasing attention in the exporting developing countries and support in the importing developed countries. International action may be highly beneficial to both partners.

1.2.3 Development potential

This paper presented in Section 1.1 a picture of the forest resources in terms of physical availability by region. In this Section, the use of these forests have been reviewed with regard to production of roundwood for industrial processing, leading to the conclusion that in many of the tropical developing countries the rate of utilization of the forest resources is low.

It may thus be necessary to evaluate the potential productivity of these resources. The biological production potential of the forest resources in the tropical zone is, of course, very high indeed. But what is important is the potential contribution of these forest resources to economic development, having regard to the possible future demand and supply situation for wood products both at the local and international levels.

The most recent in-depth evaluation was undertaken by FAO for Agriculture 2000 and published in FAO Forestry Paper No. 29 "World Forest Products - Demand and Supply 1990 and 2000".

Several possible scenarios were examined based on different assumptions concerning economic growth rates and corresponding rates of consumption for the different wood product groups. The projected situation for the year 2000 summarized below is based on the following assumption for percentage growth in consumption per annum in the period 1975-2000: sawnwood 1.2 per cent, wood-based panels 2.7 per cent and paper and paperboard 3.7 per cent.

Under these growth assumptions, world roundwood production would increase from 2 800 to 3 910 million m^3, an increase of some 40 per cent, and this would come from a rise of about 400 million m^3 in the developed world, some 300 million m^3 in the centrally planned countries, and a further

400 million m^3 in the market economies of the developing world. This would mean increases of 53 per cent for the developed market economy countries, 41 per cent for the centrally planned economy countries and only 31 per cent for the developing market economy countries, even though these last countries own some 58 per cent of the world forest resources. This projected increase has been broken down into its fuelwood and industrial wood components in Table 1.13.

Table 1.13 World roundwood production 1975 - Perspective trends 2000 (million m^3)

	1975			2000		
Region	Total roundwood	Fuelwood	Industrial roundwood	Total roundwood	Fuelwood	Industrial roundwood
Developed market economy	761	57	704	1 165	70	1 093
Developing market economy	1 305	1 112	193	1 715	1 350	365
Centrally planned economy	733	304	429	1 030	400	627
World	2 799	1 473	1 326	3 910	1 820	2 085

Wood for industries

The FAO evaluation estimates that the world production of roundwood for industrial processing might increase over the last quarter of this century by some 750 million m^3, or 57 per cent above the 1975 production level. This increase would come from some 390 million m^3 in the developed market economies, 200 million m^3 in the centrally planned economy countries and some 170 million m^3 in the developing market economy countries, and would mean for these three country groupings increases of 55 per cent, 47 per cent and 89 per cent respectively.

The study estimates that consumption of manufactured wood products would increase by about 63 per cent (including increasing use of wood residues and more efficient manufacturing). It also expects an increased consumption of wood products of some 140 per cent in the developing market economies as well as a virtual doubling of net wood exports. This net wood export trade would consist of 45 per cent of processed wood as against 22 per cent for 1975.

Table 1.14 presents a broad picture of the prospective change in the trade for the major net exporters. Additional net exports for the tropical countries are evaluated at some 80 million m^3 of hardwood logs and 95 million m^3 of pulpwood, slightly more than half of which would be hardwoods.

Table 1.14. Roundwood for industrial processing
1975 - Needs 2000
Perspective additional suppliers
(million m^3)

	1975	2000	Main additional suppliers
Broad-leaved logs	220	320	tropical countries + 80
Coniferous logs	570	862	USSR + 85, North America + 65 Europe + 20, Japan + 20
Total logs	790	1 182	
Pulpwood	540	903	North America + 110, Europe + 100, tropical countries + 95

The tropical closed forest is expected to be reduced by some 12 per cent largely due to clearing for agriculture, but harvesting is expected to increase the total output both by extending the species range and by opening up as yet unutilized areas. Technology is expected to have a favourable effect on the economics of pulp production in those countries.

In the tropics, plantations are expected to increase from some 5 million ha to over 16 million ha by 2000 and the supply of industrial wood to increase tenfold to reach some 100 million m^3. Latin America is expected to account for about two-thirds of the tropical countries' supply of industrial wood, more than 60 per cent of which is likely to be coniferous wood.

On a world basis, wood supplies are judged to be sufficient to meet the prospective demand in the year 2000 if the supply potential in the various regions can be fully realized.

In many of the developed regions, forests are managed with a view to their producing wood on a sustainable basis and forest areas are relatively stable with losses being compensated by natural reforestation of abandoned agricultural land. Areas for expansion still exist in Canada and the USSR, but much of the remainder of the developed world is pressing close to the maximum potential of the natural forest. However, industrial plantations are adding to the potential in many areas, notably Japan, Oceania and parts of Europe.

Most harvesting of industrial roundwood in tropical forests is concentrated at present on a few selected species. In West Africa, removals rarely exceed 30 m^3 per ha from forests with a growing stock of 250 to 300 m^3 per ha. Only an extension of the range of species accepted by the market will enable these forest areas to continue to supply wood in the longer term. Moreover, additional supplies will have to come from less accessible areas and from plantations. Africa and Asia, which accounted for 33 and 86 million m^3 respectively of industrial roundwood production in 1975, might reach a production respectively three and two times higher by the end of the century. These levels of production assume that both regions will be able to satisfy prospective local demand and meet most export targets. However, it might still leave some demand unsatisfied for imports of veneer, plywood and perhaps sawnwood and even logs by developed countries. Latin America is expected to be able to meet local consumption at any projection level and still have quantities potentially available for exports.

1.3 Conclusion and recommendations

1.3.1 Conclusion

This chapter has reviewed the availability of the world forest resources and their utilization for industrial purposes, with a breakdown by regions of the developed and the developing world.

An unbalanced picture emerges in which the developed world, with less than 40 per cent of the forest resources, produces almost 80 per cent of the world's industrial wood. The developing world with temperate forest has only 5 per cent of the world's forest resources and produces 7 per cent of the world total. The developing world with tropical forest possesses some 57 per cent of the world forest resources but produces only 14 per cent of the world's total industrial wood production.

On this basis the annual industrial utilization of the forest of the developed world is on average about 12 m^3 per 1 000 m^3 of growing stock; the developing regions with temperate forest average about 7 m^3; but in the developing regions with tropical forest, which represents about half of the world's growing stock of "closed operable forest", the productivity hardly reaches 1 m^3 of annual production of industrial roundwood per 1 000 m^3 of growing stock.

This paper submits that the reasons for this enormous difference in productivity is not solely due to the "less developed" effect.

With regard to the action required to promote the conservation of the forest resources in the developing world and to increase their contribution to overall social and economic development, reference is made to the report of the second meeting of experts on tropical forests, which was held in Rome in January 1982 under the joint sponsorship of UNEP, FAO and UNESCO. The meeting was attended by 34 experts from 21 countries and from 9 international governmental and non-governmental organizations.

Excerpts of their recommendations are presented below as a basis for national and international action.

1.3.2 General recommendation: Harmonization and co-ordination

The meeting of experts recognized the vital importance of the world's tropical forests for the well-being of local populations, for national socio-economic development, and for the conservation of genetic diversity. It noted the world-wide concern at the rapid destruction currently taking place.

The meeting also recognized a need to increase awareness at local, national, and global levels of the threats to the tropical forest resources, through the production of a variety of information and educational materials.

It further recognized that high priority should be given to the socio-economic aspects of tropical forest management activities, particularly to alleviate poverty of rural populations, while giving due consideration to other groups and future generations and to risk and uncertainty factors.

The meeting of experts recommended that international organizations including FAO, UNEP, Unesco and other appropriate agencies, should fully co-ordinate and harmonize their activities in the development of programmes for tropical forests. In this respect the meeting welcomed the establishment of the System-Wide Medium Term Environment Programme (SWMTEP) as an appropriate mechanism in the furtherance of this co-ordination and harmonization as a tool for rational utilization of resources.

The meeting drew attention to the very close connexion between the state of agriculture and the pressure exerted on tropical forests. It recommended that activities in agriculture and forestry should be closely co-ordinated and that all actions implemented for improvement and management of tropical forests should be accompanied by actions aiming at solving agricultural problems so as to lessen constraints and stresses due to poverty, lack of land and food of nearby populations, which can be detrimental to any form of conservation and wise use of tropical forests.

Actions at national level

The meeting recommended that:

- national efforts to be started, and supported, aiming at informing and educating the general public, promoting a better knowledge base for policy-makers, and encouraging dialogue between governmental and non-governmental agencies responsible for the development of tropical areas and related forest resources;

- tropical countries be assisted in the elaboration and implementation of national development and research programmes and management plans for forest resources development and conservation;

- in so doing, tropical countries would define their priorities, upon which only they can decide, taking into account in a balanced manner long-term and short-term efforts resulting from the forest resources development process and the various beneficiaries, viz: immediate populations, national populations and regional and international communities;

- existing capabilities in education and research be strengthened and applied as balanced inputs in forest resources development projects, so as to quickly improve skills, knowledge and methods in the management of tropical forests.

Actions at international level

The great effort required on the part of governments to undertake large-scale tropical forest resources management should stimulate increased international co-operation since the results obtained will not only benefit the countries concerned but the community of nations as a whole. This effort should be developed and undertaken with due respect to the inalienable sovereignty of the countries for the utilization of tropical forests and other natural resources of their territories. The efficiency of this co-operation could be improved by harmonizing, co-ordinating and increasing multilateral and bilateral efforts in accordance with established priorities and urgencies, avoiding gaps and duplication.

It is essential that countries which possess tropical forests participate as protagonists in this concerted international action on tropical forests, calling, where appropriate, on the support of relevant United Nations specialized agencies, international institutions, international banks, non-governmental organizations and bilateral assistance programmes. Considering that many institutions and bodies are interested and involved in the problem of tropical forestry, the meeting concluded that a co-ordinated approach and mechanism are clearly desirable.

The meeting considered arrangements for continuing review of international action on tropical forestry. It recommended that the possibility be explored for the existing FAO Committee on Forest Development in the Tropics to assume this responsibility.

GLOSSARY

Note: The glossary is valid only for this section.

Forestry Terms: based on "World Forest Inventory 1963" and "Tropical forest resources", FAO Forestry Paper No. 30.

Forest: vegetative association made up by trees

Closed forest: forest with closed canopy, in contrast with forest with open canopy which is referred to as "other wooded lands".

Operable forest or productive forest: closed forest which is considered productive; excludes forest which is classified as unproductive by legal restrictions, or because of poor quality. Some countries include economically inaccessible forests as unproductive.

Forest under management: forest with classical management plans, or any type of forest where extraction of roundwood is subject to some institutional regulation.

Growing stock: total volume of standing timber expressed as gross bole volume of trees above 10 cm diameter at breast height.

Annual increment: the volume growth per year of standing timber; sometimes expressed as "gross annual increment" without deducting natural losses, or as "net annual increment", net of natural losses.

Allowable annual cut: volume that according to management plans can be removed from standing timber without depleting forest capital.

Coniferous: refers to trees classified botanically as "gymnospermae", in the trade also sometimes referred to as "softwoods".

Broadleaved: or non-coniferous refers to trees classified botanically as "angiospermae", in the trade also sometimes referred to as "hardwoods"

<u>Forest product terms:</u> based on "Classification and Definitions of Forest Products", FAO Forestry Paper No. 32.

Roundwood: all wood in the rough as harvested in the forest.

Fuelwood: wood in the rough used as a source of energy.

Industrial roundwood: all wood in the rough not used for fuelwood.

Sawlogs and veneer logs: roundwood destined for primary mechanical wood-processing industries.

Pulpwood: wood in the rough used as a raw material input in the pulp and paper industries.

Other industrial roundwood: wood in the rough used as poles, piling and posts and other uses in the rough.

<u>Country groupings</u>

The grouping of countries used in this paper is given below. This list of countries is not comprehensive, it includes only those countries with a recognized forestry potential.

The developed regions: all developed countries are grouped as follows:

- North America: Canada and U.S.A.
- Europe: all European countries (FAO's classification)
- the USSR
- "other" developed countries: all "other" countries with direct importance for forestry: Japan, Australia, New Zealand, South Africa a.o.

The developing countries are grouped by continents, and in sub-regions on the following basis: sub-regions considered as "temperate" are marked with an asterisk.

Latin America

Central America: Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama

Caribbean and CARICOM: Cuba, Dominican Republic, French Guyana, Haiti, Suriname, Belize, Guyana, Jamaica, Trinidad and Tobago

South America-tropical: Bolivia, Brazil, Colombia, Ecuador, Paraguay, Peru, Venezuela

South America-temperate*: Argentina, Chile, Uruguay

Africa

Mediterranean: Algeria, Egypt, Libya, Morocco, Tunisia

Northern Savanna: Chad, Mali, Mauritania, Niger, Senegal, Upper Volta

West Africa: Benin, Ghana, Guinea, Guinea Bissau, Ivory Coast, Liberia, Nigeria, Sierra Leone, Togo

Central Africa: Angola, Cameroon, Central African Republic, Congo, Equatorial Guinea, Gabon, Zaire

East Africa: Burundi, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Tanzania, Uganda

Southern Africa: Botswana, Madagascar, Malawi, Mozambique, Namibia, Swaziland, Zambia, Zimbabwe

Asia

Asia Near East*: Afghanistan, Iran, Iraq, Jordan, Lebanon, Syria, Turkey

East Asia*: China, Mongolia, Korea Democratic Republic, Republic of Korea

South Asia: Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka

Continental South-East Asia: Burma, Kampuchea, Laos, Thailand, Vietnam

Insular South-East Asia: Brunei, Indonesia, Malaysia, Philippines, Fiji, Papua New Guinea, Solomon Islands

The breakdown of developing countries is done on the following basis:

Developing temperate: South America-temperate, Asia Near East, East Asia

Developing tropical: all other developing sub-regions not marked with an asterisk.

Annex Table A-1 The world forest resources by region

Regions	Population million	Operable forest: Area million ha	Volume	CON	BRT
			1 000 million m^3		
1. Developed:					
North America	246	366	36.4	26.6	9.8
Europe	485	131	14.1	8.4	5.7
U.S.S.R.	265	389	40.0	33.2	6.8
Other	168	55	5.5	3.9	1.6
Total developed	1 164	940	95.9	72.1	23.9
2. Developing:					
Temp.developing	1 432	149	12.7	..	..
Trop.developing	1 819	885	148.9	2.1	147.0
Latin America	327	522	78.5	1.2	77.3
Africa	348	162	38.8	..	38.8
Asia	1 144	201	31.5	.8	30.7
Total developing	3 251	1 034	161.6	..	..
3. World	4 415	1 974	257.5	..	..

Note: CON: coniferous; BRD: broad-leaved, non-coniferous.

Annex Table A-2 The roundwood production 1980 by region

(million m^3)

Regions	Total	Fuel-wood	Industrial roundwood					
			Total	Breakdown		Industrial categories		
				CON	BRD	SVL	PW	OIR
Developed								
North America	484	20	464	376	88	301	148	15
Europe	334	43	291	213	79	162	104	25
U.S.S.R.	356	78	278	247	31	151	38	90
Other	77	10	67	36	30	38	23	6
Total developed	1,251	151	1,100	872	228	651	312	137
Developing								
Temperate	364	265	99	65	34	52	12	35
Tropical	1,406	1,211	195	30	165	139	17	39
Latin America	337	274	63	26	37	45	12	7
Africa	417	376	41	3	38	21	2	18
Asia	652	561	91	1	90	73	3	15
Total developing	1,770	1,476	294	95	199	191	29	75
World	3,020	1,627	1,393	967	426	841	341	212

Note: CON: coniferous; BRD: broad-leaved; SVL: sawlog and veneer logs; PW: pulpwood; OIR: other industrial roundwood.

Annex Table A-3 The forest resources - detail by regions and countries

	Operable forest area in million ha	Growing stock of operable forest: Total	Growing stock of operable forest: Of which coniferous
		million m³	
1. Developed regions			
North America	366	36,400	26,600
Europe	131	14,100	8,800
U.S.S.R.	389	40,000	33,200
Other	55 a/	5,500 a/	3,900 a/
Total developed	940	96,000	72,500
2. Developing regions			
Latin America			
Central America			
Costa Rica	1.1	154	..
El Salvador	..	2	2
Guatemala	3.0	335	25
Honduras	3.0	251	67
Mexico	24.3	2,032	967
Nicaragua	4.1	519	17
Panama	2.9	489	..
Total Central America	38.5	3,782	1,078
Carribean and Caricom			
Cuba	1.0	52	4
Dominican Republic	.6	24	5
Guyana Fr.	7.6	2,200	
Haïti	..	1	..
Suriname	12.5	3,611	
Carribean and Caricom (cont.d)			
Belize	.9	49	1
Guyana	13.5	2,289	
Jamaica	..	5	
Trinidad and Tobago	.1	21	
Total Carribean and Caricom	36.2	7,252	10
S. America tropical			
Bolivia	30	3,063	-
Brazil	301	47,088	98
Colombia	39	5,046	-
Ecuador	11	1,349	..
Paraguay	3	194	-
Peru	44	8,137	12
Venezuela	19	2,726	-
Total S.America tropical	447	67,603	110

	Operable forest area in million ha	Growing stock of operable forest: Total (million m3)	Of which coniferous (million m3)
South America temp.			
Argentina	5	..	..
Chile	4	..	..
Uruguay	..	..	..
Total S.America temp.	9.1	1,200 a/	25
Total Latin America	530.7	79,837	1,223
Africa			
Mediterranean			
Algeria		..	..
Egypt		..	
Libya		-	
Morocco		..	
Tunisia		..	
Total Meaiterranean	0.2	40 a/	..
Northern Savanna			
Chad	.5	60	
Mali	-		
Mauritania	-		
Niger	-		
Senegal	..	2	
Upper Volta	-		
Total N. Savanna	0.5	62	..
West Africa			
Benin	..	6	
Ghana	1.3	198	
Guinea	1.4	257	
Guinea Bissau	.4	25	
Ivory Coast	3.3	766	
Liberia	1.3	220	
Nigeria	3.0	492	
Sierra Leone	.2	35	
Togo	.6	38	
Total West Africa	11.3	2,037	
Central Africa			
Angola	2.4	270	
Cameroon	17.0	4,645	
Central African Rep.	3.5	1,102	
Congo	13.7	4,310	
Equatorial Guinea	1.0	212	
Gabon	19.9	4,699	
Zaïre	80.1	20,014	
Total Central Africa	137.6	35,252	

	Operable forest area in million ha	Growing stock of operable forest: Total (million m³)	Of which coniferous (million m³)
East Africa			
Burundi	..	1	
Ethiopia	1.6	136	54
Rwanda	..	7	
Kenya	.5	61	9
Somalia	.1	8	3
Sudan	.3	38	..
Tanzania	.8	94	
Uganda	.7	86	
Total East Africa	4.1	431	66
South Africa			
Botswana	..	..	..
Madagascar	6.7	740	..
Malawi	..	5	
Mozambique	.5	24	..
Namibia	..	..	..
Swaziland	..	..	..
Zambia	2.3	239	..
Zimbabwe	..	..	..
Total South Africa	(9.5)	(1,008)	..
Total Africa	162.4	38,830	66
Asia			
West Asia Near East			
Afghanistan	..	300 a/	..
Iran	..	600 a/	
Irak	..	..	
Jordan	..	..	
Lebanon	..	..	
Syria	..	..	
Turkey	8.1	926	
Total West Asia Near East	15 a/	1,826 a/	(1,100)
East Asia			
China	122	(9,500)	(5,300)
Korea Democratic	..	30	
Korea Republic of	..	130	
Mongolia	..	40	
Total East Asia	125 a/	9,700 a/	(5,300)

	Operable forest area in million ha	Growing stock of operable forest: Total (million m³)	Growing stock of operable forest: Of which coniferous (million m³)
South Asia			
Bangladesh	.8	68	
Bhutan	1.8	374	113
India	42.9	3,058	470
Nepal	1.3	95	22
Pakistan	1.1	170	139
Sri Lanka	1.2	76	
Total South Asia	49.1	3,842	744
Continental South-East Asia			
Burma	23.9	3,811	16
Kampuchea	5.4	1,163	1
Lao	3.6	644	10
Thailand	4.6	325	10
Vietnam	3.8	708	9
Total Continental South-East Asia	41.3	6,651	47
Insular South-East Asia			
Brunei	.3	84	
Indonesia	73.7	13,823	13
Malaysia	15.6	3,735	
Philippines	6.9	1,543	18
Fiji	..	..	
Papua New Guinea	14.1	1,817	31
Solomon Islands	..	..	
Total Insular South-East Asia	110.6	21,002	31
Total Asia	341	41,700	7,163
Total Developing World	1,034	161,600	(8,700)
Total temperate developing	149	12,700	6,640
Total tropical developing	885	148,900	2,060
3. World	1,974	257,500	..

Source: FAO Forestry Paper No. 30; Various other FAO Trend and Appraisal Studies

Notes: a/: estimate ..: small quantity
Data between brackets: estimates known to be incomplete

Annex Table A-4 The industrial roundwood production 1980

	Industrial roundwood		By industrial categories		
	Total	of which coniferous	SVL[a]	PW	OIR
1. Developed regions					
N. America	464	376	301	148	15
Europe	290	213	162	104	24
USSR	278	247	151	38	89
Other	66	36	38	23	5
Total developed regions	1,098	872	652	312	134
2. Developing regions					
Latin America					
Central America					
Costa Rica	1.50		1.35	-	0.15
El Salvador	0.09	0.03	0.07		0.02
Guatemala	0.16	0.10	0.15		0.01
Honduras	1.06	1.03	1.05		0.01
Mexico	6.35	5.78	3.47	2.64	0.14
Nicaragua	0.88	0.35	0.83		0.05
Panama	0.05	..	0.04		0.01
Total Central America	10.00	..	7.00	2.64	0.36
Caribbean and Caricom					
Cuba	0.39		..	-	0.35
Dominica Rep. of	..		..	..	..
Guyana Fr.	0.09				..
Haiti	0.24		0.22	..	..
Suriname	0.37		0.34	..	..
Belize	0.05		..		
Guyana	0.16		0.15	..	..
Jamaica	0.02		0.02	..	..
Trinidad and Tobago	0.06		0.06	..	..
Total Caribbean and Caricom	1.38		0.79	-	0.59

	Industrial roundwood		By industrial categories		
	Total	of which coniferous	SVL[a]	PW	OIR
South America Tropical					
Bolivia	0.44		0.40	-	..
Brazil	42.92	19.02	29.67	8.58	4.67
Colombia	3.00	0.50	2.31	0.30	0.12
Ecuador	1.72		1.65	-	0.07
Paraguay	1.54	..	1.20	-	0.34
Peru	1.71	..	1.10	..	0.59
Venezuela	0.64	0.10	0.61	-	0.03
Total S.America Tropical	51.97	19.62	36.94	8.9	6.13
South America Temperate					
Argentina	4.79	1.22	1.52	2.43	0.84
Chile	8.17	7.16	4.78	3.06	0.18
Uruguay	0.38	-	0.25	0.06	0.08
Total S. America Temperate	13.34	8.38	6.55	5.55	1.24
Total Latin America	76.88	35.51	51.44	17.18	7.96
Africa					
Mediterranean					
Algeria	0.20	0.14	0.02		
Egypt	0.08				
Libya	0.09				
Morocco	0.40	0.06		0.20	
Tunisia	0.11	0.05	..		
Total Africa Mediterranean	0.88	0.25	0.13	0.20	0.55
Northern Savanna					
Chad	0.45	-	-	-	
Mali	0.27	-	0.1	-	
Mauritania	0.04	-	-	-	
Niger	0.21	-	-	-	
Senegal	0.48	-	0.02	-	
Upper Volta	0.30	-	..	-	
Total N. Savanna	1.75	-	0.03	-	1.72

	Industrial roundwood		By industrial categories		
	Total	of which coniferous	SVL[a/]	PW	OIR
West Africa					
Benin	0.20	-	0.02	-	
Ghana	2.52	-	2.14	-	
Guinea	0.53	-	0.18	-	
Guinea Bissau	0.10	-	0.04	-	
Ivory Coast	5.48	-	4.98	-	0.50
Liberia	0.86	-	0.74	-	0.12
Nigeria	7.36	-	5.08	-	
Sierra Leone	0.16	-	0.04	-	
Togo	0.15	-	0.02	-	
Total W. Africa	17.36	-	13.24	-	4.12
Central Africa					
Angola	1.29	-	0.56	0.14	
Cameroon	2.17	-	1.60		
Central African Rep.	0.45	-	0.32		
Congo	0.80	-	0.60		
Equatorial Guinea	0.05	-			
Gabon	1.10	-	1.10		
Zaire	2.26	-	0.30		
Total C. Africa	8.12	-	4.48	0.14	3.50
East Africa					
Burundi	0.04				
Ethiopia	1.44	0.15	0.20	0.17	
Kenya	1.16	0.48	0.37		
Rwanda	0.06				
Somalia	0.06		0.03		
Sudan	1.53		0.04		
Tanzania	0.99	0.18	0.29		
Uganda	1.43	0.02	0.11		
Total East Africa	6.71	0.83	1.04	0.17	5.50
Southern Africa					
Botswana	0.05	..	..		
Madagascar	0.81	..	0.47		
Malawi	0.31	0.03	0.08		
Mozambique	0.84	..	0.19		
Namibia	..	..	..		
Swaziland	2.06	1.87	0.33	1.67	
Zambia	0.47	0.01	0.13		
Zimbabwe	1.17	0.26	0.44		
Total S. Africa	5.71	2.17	1.64	1.67	2.4
Total Africa	40.53	3.25	20.56	2.18	17.8

	Industrial roundwood		By industrial categories		
	Total	of which coniferous	SVL[a]	PW	OIR
Asia					
Asia Near East					
Afghanistan	1.52	0.95	0.86		0.66
Iran	4.38		0.37		4.01
Irak	0.02		0.02		
Jordan	..		..		
Lebanon	0.02		0.02		
Syria	..		..		
Turkey	7.31	6.6	5.15	1.03	1.13
Total Asia N. East	13.25	10.55	6.42	1.03	5.80
East Asia					
China	68.10	43.00	36.00	5.30	26.80
Korea, Dem. Rep.	0.60		0.60		
Korea, Rep. of	8.72	2.19	1.69	0.23	
Mongolia	1.00	0.80	1.00		
Total East Asia	72.40	56.55	39.30	5.50	27.80
South Asia					
Bangladesh	0.89		0.86	0.06	
Bhutan	..	..	..	..	
India	8.62	1.18	3.39	1.21	4.02
Nepal	0.56	0.20	0.56	-	
Pakistan	0.54	0.14	0.52	-	
Sri Lanka	0.60		0.14	-	
Total South Asia	11.21	1.52	5.47	1.27	4.47
Continental South East Asia					
Burma	2.96		1.91	-	1.05
Kampuchea	0.57		0.11	-	0.46
Lao	0.22		0.13	-	0.09
Thailand	4.88		2.43	-	2.45
Vietnam	2.74	0.11	1.31	-	1.43
Total Continental South-East Asia	11.37	..	5.89	-	5.48

	Industrial roundwood		By industrial categories		
	Total	of which coniferous	SVL[a]	PW	OIR
Insular South-East Asia					
Brunei	0.10		0.13	-	
Indonesia	24.20	0.63	21.8	..	2.36
Malaysia	32.60	..	31.48	0.61	0.53
Philippines	9.20		6.35	0.82	2.00
Fiji	0.20		0.16	-	
Papua New Guinea	1.40		1.19	0.17	
Solomon Islands	0.30		0.31	-	
Total Insular South-East Asia	67.90		61.41	1.60	4.90
Total Asia	176.60		118.00	9.40	48.75
Total Developing	294.00	95.00	191.00	28.50	75.00
Total developing temperate	99.00	65.00	52.00	12.00	35.00
Total developing tropical	195.00	30.00	138.00	17.00	40.00
3. World	1,393.00	967.00	841.00	341.00	212.00

Source: FAO Yearbook of Forest Products.

a/ For abbreviations, see footnote of Annex Table 2.

Notes: 1) In the above table some differences may occur with regard to totals, as for simplicity reasons the above list does not include either small countries or those without forest production data.

2) - = zero; .. = small quantity; open space = no information.

Annex Table A-5 Roundwood production situation 1975. Projected situation 2000

(million m^3)

	1975			2000		
	Total roundwood	fuelwood	Industrial roundwood	Total roundwood	fuelwwod	Industrial roundwood
Developed market economies	761	57	704	1,165	70	1,093
N. America	454	18	436	670	28	642
W. Europe	229	29	200	350	30	320
Oceania	22	1	21	60	2	58
Japan	37	-	36	58	-	58
Other	19	8	11	25	10	15
Developing market economies	1,305	1,112	193	1,715	1,350	365
Africa	327	294	33	360	300	60
Latin America	309	250	59	525	400	124
Far East	502	495	87	760	600	161
Near East	87	73	14	70	50	20
Centrally planned economies	733	304	429	1,030	400	627
USSR and Eastern Europe	468	96	372	630	100	531
Asia	265	208	57	400	300	96
WORLD	2,799	1,473	1,326	3,910	1,820	2,085

SECTION 2: LOGGING AND TRANSPORTATION

2. Logging and transportation

2.1 Introduction

The logging and transportation sector of the forest industry exists mainly to provide raw material directly to the mechanical wood products and/or chemical wood products sectors. However, when logging is carried out to export sawlogs and veneer logs or to produce poles and piling or fuelwood, it is an industry on its own. Although the export of logs may yield lower social and economic benefits than further manufacture within the country, those countries with a forest resource and in need of immediate development may find it an attractive option. Regardless of which end use is to be made of the product, logging provides an important proportion of the employment within the industry and a very large role in rural development.

While the nature and extent of the forests have major bearing on logging potential, the volume and characteristics of the wood which can be logged are limited by the requirements of the available markets. Furthermore, constraints on the volume available for harvesting annually, and on the types of logging systems which can be used, may be applied by silvicultural and environmental requirements and government policies. Examples of these constraints include allowable annual cut limitations, protection forests, and partial cutting requirements.

Differing forest and differing terrain require different techniques of harvesting to ensure an efficient operation; a minimum of interference with environmental values of the forest; and a maximum assurance that the stands will be maintained or regenerated. The care exercised in harvesting must also be extended to the design and construction of the road system which is almost always required, and if done incorrectly is difficult to remedy.

Logging must provide an adequate sustained supply of raw material for the conversion plant or plants with which it is associated to assist in efficient operation of that sector. Consequently, all phases of logging and transportation must be coordinated into a well-planned operation by experienced professionals.

2.2 Forest utilization contracts

Forest lands may be under either private or public ownership. In some countries - Sweden and the United States, for example - privately-owned lands make up a very significant proportion of the forest resources. In others, most of the forest has been retained as public land. The forests of the developing countries fall largely into the latter category.

One of the options which is available for the utilization of a public forest resource is the disposal of forest land by grant of sale. Disposal of forest lands from one public body to another public or semi-public body in this manner sometimes takes place but outright disposal to private interests is very rare. Another option is for the public body itself to establish a logging operation and a conversion plant on its own behalf or to carry out its own logging operation for sale as roundwood on the open market. However, the option most frequently used is to issue a forest utilization contract which provides the right to harvest timber but does not give title to the land.

Forest legislation and forest regulations, as well as the utilization contracts themselves, govern the manner in which public objectives are to be met. However, public objectives may change with the prevailing state of forestry and the forest industry. In the very early stages of social development, the objective may be to obtain as much revenue as possible even if this involves uncontrolled exploitation. At a later stage, the public owner should recognize the importance of the forests as a basic factor in social and economic progress and re-define forestry objectives accordingly. At this stage more sophisticated legislation and contract provisions become necessary and a strong forest authority is required for their implementation.

2.2.1 Classification of forest utilization contracts

Forest utilization contracts, although they may come under many names, are of two main types - timber harvesting contracts and forest management contracts. Timber harvesting contracts can be further classified by term - short (1 - 5 years), medium (5 - 15 years), and long-term (over 15 years). By their nature, forest management contracts are long-term. A further form of contract, called a forest exploration contract, gives the exclusive right to investigate a particular forest for a specified time as a prelude to a long-term utilization contract. The two main types of contract are discussed in the following sections.

2.2.2 Timber harvesting contracts

Timber harvesting contracts give the right to undertake logging in a determined area without the responsibility for forest management, although the silvicultural cutting regime is usually laid down and the quantity or area to be harvested anually or periodically is specified. The rights may sometimes be restricted to the removal of certain species or particular grades, such as pulpwood, sawlogs or veneer logs. Timber harvesting contracts are usually short- or medium-term. They may, however, be long-term contracts if they concern forest land to be converted to other uses, or when granted over areas of permanent forest land.

In many countries, in the early stages of forestry, the only form of forest disposal from public land is under short- or medium-term harvesting contracts which leave considerable freedom to the grantee with regard to harvesting techniques, utilization standards and road construction methods. Such contracts basically provide that the entrepreneur receives the right to cut wood and in exchange to pay fees to the owner. In a more advanced stage, the owner will, however, plan and control the utilization more intensively; the annual exploitable volume will be fixed, the cutting area delimited and the trees to be removed marked, probably by the forest service; the logged area will be inspected and wasteful logging methods penalized. At this stage the operations of the grantee come more and more under close supervision by the forest service. Increased supervision, of course, entails a sufficient number of well-trained staff, lack of which in some countries delays the full implementation of the regulations.

With increasing interest in better utilization, the owner may introduce other forms of wood disposal, such as the sale of standing timber, which will allow better control of operations and perhaps give higher prices. Short- and medium-term harvesting contracts may be replaced by sales based on stumpage derived from public auctions or tenders.

A FAO study carried out in 1975 showed that Indonesia, the Philippines and Malaysia, the three main producers of tropical hardwood logs, had about 26 million hectares under forest utilization contracts. A further 40 million hectares was under contract in West Africa.

The term of timber utilization contracts can be very important in forestry development. Short-term contracts involve the least risk for the forest owner in financial terms, but can involve high risks for the entrepreneur. If adequate capital investments cannot be amortized during the term of the contract, investment will be kept to a minimum so that operating costs are high and only the most accessible and most valuable logs will be harvested. In addition, there may well be considerable damage to the forest and to the environment as the concession holder attempts to make as much money as possible in the short time available.

Long-term contracts offer much better opportunities for the entrepreneur and can lead to complete integration of logging and wood processing with many possibilities for rationalization. Consequently, long-term contracts may well be one of the more important instruments for encouraging industrialization. However, in making a commitment for long-term cutting rights over a large area, a forest owner must pay close attention to the environmental values of the forest, to the problems of forest regeneration, and to the objective of public revenues as log values change over time. The utilization contract must contain provision which meet these objectives and allow for changes as values or objectives change, and the regulatory authority must be strong enough to enforce them.

Some countries vary the term of the contract by the nature of the operation. In the Ivory Coast, for example, logging operators may apply for five-year contracts; sawmill operators for one of ten years; and veneer mills or integrated industries for one of fifteen years.

2.2.3 Forest management contracts

Forest management contracts place the responsibility for parts or all of forest management on the grantee. The grantee may have to do inventory work on which the silvicultural systems and management plan will be based, the determination of the allowable cut, the preparation and periodic revision of the logging plan, experimental work such as permanent sample plots and all other operations prescribed in the management plan. The state forest service checks the data prepared by the company and supervises its activities. A forest management contract is in its nature a long-term arrangement which usually offers a satisfactory way of ensuring proper management of the forest.

Efficient management of public forest lands by the private sector can be found in the long-term "Tree Farm Licences" of British Columbia and other Canadian provinces. Similar tenures have been established in Mexico and the initial steps have been taken in the Philippines and other countries.

A special adaptation of a forest management contract might be required where plantations are to be developed through afforestation.

2.2.4 Methods of allocation

In some countries the initiative to apply for a utilization contract is left to the entrepreneur. In others, the government advertises the forest areas for which contracts are to be granted and invites applications. This latter method has certain advantages for the forest owner as he can choose the time of sale and the areas that he deems appropriate for the time and conditions of the forest. In addition, the public invitation may attract many applicants and permit the owner to choose the one he considers the most appropriate.

Several methods may be used to select a successful applicant. The easiest method is to award the contract to the applicant who had first shown interest. Another method may be to select the offer which will yield the highest revenue. A third, the most commonly used today for long-term contracts, is to award the contract after a careful analysis of the relative merits of all offers with regard to revenue, capital investment, employment, forest practices, proposed type of utiliztion, and the reputation and experience of the applicant in the forest industry. The main disadvantage of this latter method is the extent to which subjective judgement must influence the final choice. However, if objectives have been clearly defined before the forest is offered, the judgement need not be too difficult.

The formulation and award of a long-term contract may require approvals through many agencies and levels of these agencies. For example, the content may require review by the agencies concerned with wild life, fisheries, water, land use, and even tourism, both at the technical levels and at the executive levels. Unless there is a well-defined procedure for processing applications, the progress may be both time-consuming and frustrating.

2.2.5 Forest fees and charges

Forest fees include all payments which must be made to harvest wood from a particular area. These may include a fee when the contract is awarded; fees for specific purposes such as forest protection, inventory, silviculture or forest management; area fees or land rentals which are usually low but may be relatively high to discourage speculation; and fees for the logs themselves. The fees for the logs themselves, commonly called "stumpage", are usually most important both to the forest owner and to the contractor.

Stumpage rates can be and are determined in many ways. In some cases, stumpages are assessed in accordance with a fixed schedule established by legislation or regulation usually for a whole country or a broad geographic region and frequently in effect for long periods. In others, particularly for short-term utilization contracts, they are established by competitive bidding by all interested parties. In others again, by negotiation between the owner and the entrepreneur. And, finally, by the application of a stumpage appraisal system which recognizes differences in species and grade values and in expected logging costs. Stumpage appraisals may also be undertaken to establish minimum levels for competitive auction and as a basis for negotiating rates. Stumpage appraisals have now been extended to consider selling prices of the primary products such as lumber and chips.

Determination of stumpage fees which will permit economic harvesting but still give adequate returns to the forest owner is one of the major problems of forestry in many countries. Stumpage levels have strong implications for wood utilization standards. If stumpage rates are not realistically related to species and grades, there is a strong incentive for logging to be over-selective and wasteful, with recoveries limited to higher-value logs and easily accessible stands. A stumpage determination system which takes into consideration selling prices, logging and manufacturing costs, and recovery rates of the various species is one of the necessary conditions for the introduction of better utilization standards. Very low rates can be used as an inducement to utilize species for which there is not an established market. For long-term contracts, to ensure equitable rates for both parties, provision must be made for periodic revisions in stumpage rates in accordance with changing market conditions.

Forest fees are not the only benefits which a state receives from an active forest industry. For example, additional revenue may be realized from corporate and personal income taxes and other values from increased employment. Some jurisdictions, British Columbia, for example, have greatly expanded forest activities by offering forest stands previously considered to be below sawmilling standards at low stumpage rates.

2.2.6 Control of utilization contracts

In all utilization contracts, provision must be made to allow the owner to verify that the contractor is fulfilling all his obligations and for penalties to be applied where performance has not been adequate. For satisfactory control both the obligations and the penalties must be clearly defined either in the contract or in the forest legislation and regulations. Penalties must be commensurate with the severity of the offense. Provision should be made for arbitration in the event of a disagreement over interpretation of the provisions of the contract.

Control will have to be exercised in the planning stage over the forest inventory, logging development plan, standards for road construction and maintenance, and planned silvicultural activities. At the operational level, it will have to be exercised by field checks to assess compliance with agreed plans; observance of utilization rules and road, environmental and silvicultural standards; damage to residual stand; and regulations governing log marking, measuring and transportation.

Control must be exercised in such a way that it will not unnecessarily complicate, hinder or delay, or even stop the work by the contractor. To exercise effective control without unnecessarily impeding the work, the state must maintain an efficient, technically competent and adequately trained staff large enough to effectively supervise all contracts.

2.3 Logging methods

A vast assortment of equipment has been developed for use in logging. Equipment for felling trees ranges from a simple inexpensive axe to a sophisticated track-mounted shear which can fell large trees in a single motion. Moving logs from the stump to the roadside may involve no equipment at all - using only manpower or animal power - or it may involve farm tractor, articulated skidders, crawler tractors, mobile spar yarders or even helicopters. The choice of equipment for use in the final transportation to market is almost equally wide, and within each classification of equipment there are many models of differing capacities and costs.

Development of this assortment of logging methods and equipment has not been accidental - tremendous variations exist in the timber, terrain, topography and climate and in the socio-economic conditions under which forest harvesting is carried out, each of which influences the selection of the logging system and the equipment used within the system. The situation is not static. A very simple labour-intensive system may well meet the needs of a country in the early stages of development, but a more capital-intensive mechanized system is likely to be more suitable to support larger conversion plants at a later stage.

2.3.1 Factors in the selection of a logging system

There are four main logging systems:

- mechanical ground skidding;

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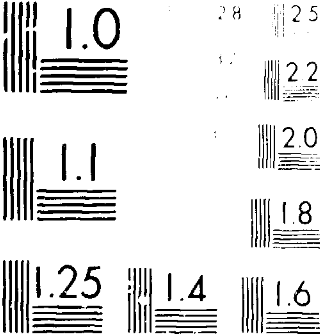
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- cable systems;
- other mechanical systems; and
- manual/animal systems.

Selection of the appropriate logging system is heavily dependent on the forest itself. In some forests both natural conditions and markets combine to permit clear cutting; in others, either silvicultural or environmental conditions or market limitations make partial cutting necessary. In either case, the actual loggable volume per unit area and the total loggable volume in the stand have important implications for logging costs, both capital and operative. In addition, partial cutting seriously reduces the efficiency of most mechanized logging systems.

The dimensions of the trees to be logged and the weight of the wood will, together with market specifications, determine log sizes and influence the power requirements of the equipment to be selected.

Terrain, topography and climate bear heavily on the selection of appropriate logging systems. Steep slopes limit the effectiveness of skidders and tractors and hence favour the selection of cable systems. Soils which are subject to compaction may require the use of low ground pressure equipment or cable systems to avoid conditions detrimental to growing the next crop. Soil of low load-bearing capacity will increase the amount of road ballast required and hence, will increase the cost of road construction. Scarcity of gravel may further increase the cost so that longer skidding distances and less road construction become necessary. Heavy rainfall and poor soil conditions may limit the operating season and thus increase the quantity of equipment required to meet an annual operating target. A short operating season usually increases logging costs substantially.

Poorly planned logging and poorly constructed roads can have detrimental effects on soil erosion, watershed management, wildlife habitat and recreational and aesthetic values, in addition to raising costs. Logging systems must be planned to conform to government regulations and to avoid these ill effects.

Selection of systems also depends on the availability of manpower and its training and experience. Sophisticated equipment depends on highly skilled men for its operation and maintenance; where such skills are lacking, it is advisable to keep equipment as simple as possible. Simple equipment, too, is more likely (than complicated machines) to meet government needs for increased employment and minimum use of foreign exchange. Availability of foreign exchange can be important not only at the beginning of a project but throughout its life, as replacement parts as well as fuel and lubricants must be imported in many developing countries.

2.3.2 Mechanical ground skidding

Mechanical ground skidding is the term used to describe the system where logs are dragged behind wheeled or tracked vehicles. The system is used in most forest regions of the world.

Crawler tractors can operate on slopes up to 40 or 50 per cent favourable grade and 10 to 20 per cent adverse, but ground travel by crawlers is relatively slow. Articulated wheeled skidders can operate on slightly lower slopes - 30 to 35 per cent favourable grades - and are designed for fast hauling. Although either may be used alone, in tropical forests crawlers and skidders are frequently used in combination with one to three tractors gathering logs over short distances for one skidder. The skidder then drags the logs for distances up to 1.0 to 1.5 kilometers to roadside. In this manner logs can be moved quite rapidly over substantial distances and expansive road construction can be kept to a minimum. While it is fast, a wheeled skidder is quite sensitive to adverse grades and loses effectiveness significantly in broken ground. Similarly, productivity is lost in very wet ground.

Ground skidding is particularly well suited to partial cutting in tropical forests as vehicles can be manoeuvred among the standing trees with relative ease. In some South American forests, extraction of volumes as low as 15-20 m^3/ha has been found profitable.

Crawler tractors have been in use for many years for various purposes, and men experienced in their use can be found in most countries. This degree of familiarity simplifies training of operators for tractors and skidders in logging. Still, trained and experienced planners and supervisors are required to obtain an efficient operation and to avoid silvicultural and environmental damage. Under good conditions in tropical forest, crawlers can produce about 40 m^3/8-hour shift and articulated skidders about 80 m^3.

Skidders and crawlers can be purchased in many sizes. The best size for a particular operation will depend on the size and weight of the logs and the ground conditions in the forest. A unit consisting of two medium-sized tractors and one heavy duty skidder can cost US$350,000 to US$400,000. A relatively new high-speed tracked skidder may help to overcome wheeled skidders' problems in broken terrain and very wet ground, and raise the upper slope limit to ground skidding.

2.3.3 Cable systems

Cable systems are those systems which involve the use of moving lines; a winch which is stationary while in service and one or more spars or masts to give elevation. Logs are either partially or entirely off the ground as they are moved. Many variations exist, of which "high lead", "skylines" and "cable cranes" are primary examples. In the high lead system, the winch and spar are frequently mounted on wheels or tracks to form a "mobile yarder". In the Philippines, wooden spar trees are still being rigged in some locations.

The primary advantage of cable systems is that they can be used on steep slopes and broken terrain or over swampy ground where other systems have serious disadvantages. However, cable logging requires intensive planning, well-trained experienced crews and expensive equipment, so extraction costs tend to be high. The systems are best adapted to clear cutting in blocks or strips. Low recovery per hectare, damage to residual trees, and difficulties in changing cable alignments tend to limit effectiveness in partially cut forest. Productivity varies with the terrain, road spacing, piece size, volume/unit area and the size of area logged at each setting.

Heavy duty cable systems are in use in western North America, the Philippines, and Borneo. Lighter systems are in use in mountainous regions of Europe and some developing countries in Latin America and Asia. Very light systems are now being developed for use in small timber and thinning operations in North America, Europe and Japan.

The productivity of mobile yarders operating in clear cut areas in developed countries has been reported as follows:

	m^3/8-hour shift
Small yarder	30 - 80
Medium yarder	100 - 180
Large yarder	110 - 250

For a partial cut operation in Southeast Asia, productivity of a large yarder ranges from 55 to 120 m^3 per shift.

A heavy duty mobile yarder of the type used in western North America can cost in excess of US$500,000.

2.3.4 Other mechanical systems

The classification "other mechanical systems" includes a variety of equipment which has been designed for other uses but has been adapted for logging. The advantages are that the equipment is simple to operate, easy to maintain, usually readily obtainable and inexpensive. Most of the operations where this type of equipment is used are labour intensive. Disadvantages include a requirement both for favourable terrain and favourable weather conditions.

Some systems are based on the use of a simple lorry. For example, in Malaysia and Indonesia, crawlers are used to skid logs to very rough roads, little better than skid trails. A self-loading lorry equipped with all-wheel drive, power take-off, and an A-frame, is then used to transport logs direct to a logyard or a mill yard. Use of this system is limited to reasonably dry soils and usually to slopes below 30 per cent. Vehicles are frequently old military surplus. Operations are usually on piecework and crews and drivers can do much of the maintenance. Consequently, costs can be kept reasonable even though the operating season may be short. A somewhat similar system is used on plantations in South Australia.

In Nigeria, small lorries are driven over very rough roads to the stump where they are loaded by hand winch or jacks. Again this method requires dry weather and easy terrain. Costs of about US$21 50/$m^3$ were reported in 1977 which compare favourably with those of more sophisticated systems used in a broader range of ground and weather conditions.

The use of farm tractor for ground skidding has become common in the United Kingdom and Europe and manufacturers have developed many attachments for use in logging. Skidding is usually effective on slopes up to about 30 per cent. Towers have also been developed to convert farm tractors into light cable cranes. Farm tractors and trailers are used to forward small logs on good ground. A farm tractor equipped with grapple crane and trailer can be a very effective unit for moving pulpwood billets.

The mechanical systems using converted equipment are seldom adequate to supply large conversion plants as their productivity is low, but they may provide an important supplemental source.

2.3.5 Manual/animal systems

Some systems depend very heavily on manpower to produce logs. Many push or pull, roll or slide, throw or carry, logging operations still exist which may produce logs cheaper than mechanized operations under appropriate conditions. An excellent example is the Kuda Kuda system used in Borneo to harvest forests in freshwater swamps. Under this system men are harnessed to the logs and pull them over a skid-way to a light railway where they are loaded, again manually, onto rail cars. A 1981 report shows a total cost of US$19/$m^3$ for all phases of the operation.

Other systems depend on animals. Some small operations in developed countries still use horses. Malawi is training oxen to skid logs. Elephants, buffalo and bullocks are still used extensively in Asia. Reports from India show that a pair of buffaloes can move 2 to 3 m^3/day over 500 m at a cost of US$0.90 - US$1.00/m^3. An elephant can move 6 to 8 m^3/day over a similar distance at a cost of US$2.50 - US$3.25/m^3. It can load 40-50 m^3/day at a cost of US$0.40 - US$0.55/m^3.

The major problem with manual/animal systems is the physically demanding nature of the work and the natural reluctance of people to continue in work of this nature. Maintaining an adequate raw material supply to an industrial complex using these systems can be extremely difficult due to the vast number of people and/or animals which are required.

2.3.6 Ancillary functions and equipment

Discussion to this point has been concerned primarily with systems for moving logs from the stump to an assembly point for further transport. However, these systems are only part of the logging process. Trees must be felled before they can be moved. Roads must be available for use when and where they are required. Maintenance facilities must be available to ensure that equipment is ready for use when it is needed. These functions, although they are called "ancillary functions" here, are just as important as the basic systems.

Felling and log-making

As for most logging functions, the equipment for felling and log-making may be quite simple or it may be highly sophisticated. At one extreme, axes and saws are still in use in many regions of the world. At the other, track or wheel mounted self-propelled mechanical shears which can fell a tree with a single movement are used in some regions where labour costs are high. Some of these machines are very sophisticated indeed, with the same machine incorporating the functions of felling, log-making, and log transportation. Most are restricted in use to flat or gently sloping terrain.

The most common instrument for industrial tree felling and log-making, however, is the chainsaw. This inexpensive (US$600 to US$1,000) but highly productive machine is known and used throughout most of the world. Many effective makes and sizes are available. Selection should be based on appropriate weight, horsepower and blade length for the timber and terrain concerned and upon the availability of service facilities. Chainsaws have a relatively short life and must be replaced after six months to two years of steady use. Adequate stocks of spare-parts, files and other tools, and replacement cutting chains are essential. For an efficient and safe operation, both operators and maintenance men must be highly trained. Felling by any means but the most sophisticated is a hazardous operation and training in safe methods is essential if the workers' welfare is to be taken into account.

Roads and road construction

In some well-developed forest regions, the existing road system may be adequate for all logging needs. Alternatively, waterways may be such that no road construction is necessary. In most regions, however, roads must be built before the forest can be logged. Planning and constructing the road system is usually one of the most important functions of logging.

The objective in a well-planned logging operation is to select a logging system, a road density and a transportation method, so that the combined costs of road amortization, road maintenance, skidding or yarding, and main log transportation are kept to a minimum. A second objective, which may be equally important, is to locate and construct the road network so that environmental hazards are avoided.

In tropical forests, the basic machine for constructing subgrade is the crawler tractor as it has been in most temperate countries. Recently, however, in North America power shovels and backhoes are being used increasingly for this purpose and these machines may also have advantages for use in the tropics. In rocky terrain, mobile rock drills and explosives are frequently required. Surfacing usually involves the use of gravel trucks, gravel loaders, and a grader and may also involve scrapers and compactors. The capital cost of a construction unit including a heavy duty crawler, a gravel loader, three gravel trucks, and a grader can be in the US$800,000 - US$900,000 range. The other extreme is a small operator who uses only a crawler tractor for road construction.

The standard to which roads must be built depends on the size and number of loads to be carried and the length of time the roads will be in use. For example, in natural forests where rotations are long, some of the feeder roads may be needed only for a short time and for a small volume of wood. Such roads can be of a much lower standard than secondary and main roads which may be in use for many years and carry a large volume of wood. Where very large volumes of wood are concerned or where long-term use is contemplated, hard-surfaced main roads should be considered for greater speed and lower maintenance costs on roads and trucks. In plantations with relatively short rotations, all roads should probably be built to approximately the same standard.

Road construction costs cover a very wide range. In the steep rocky terrain of western North America, road costs average US$50,000 to US$60,000/km but costs of US$100,000 are not uncommon. Such high costs encourage the use of long-distance skylines. In Indonesia, main roads are being constructed for about US$25,000 to US$35,000/km. Road requirements vary from about 10 m/ha in tropical forests to about 35 m/ha in very intensively managed forests on steep terrain in Europe.

To ensure a stable road-bed, roads should be built at least a year before they are to be used. Consequently, lead time of substantially more than a year is required to accommodate the planning and engineering which must precede construction.

Loading and unloading

Wherever trucks are used for transport, logs must be loaded in the forest and unloaded at destination. The objective in loading and unloading is to get the truck back on the road as rapidly as possible. Many loading methods are in use, ranging from rolling logs up a ramp by manpower, through use of a gin-pole and winch, to use of knuckle boom cranes, front-end loaders and heavy duty heel-boom cranes. The principle involved in the selection of the equipment is the same as for other phases of logging - lowest overall cost. For example, in a particular situation the lowest loading cost might be achieved by a manual loading method, but the time required would significantly reduce the efficiency of an expensive truck and actually increase overall costs. Consequently, for most operations some form of loading machine is used. The size and weight of the pieces to be handled, soil conditions, size of available landings, the distance between landings, and the comparative cost of the machines all enter the final selection. This selection, of course, should not be made to solve the short-term problems of an immediate situation but should consider all situations expected to be met over the life of the machine. One of the most difficult problems in logging planning is to determine the number and type of loaders which will ensure that loading will not be a bottleneck in the system. Capital cost is important, as the cost of a medium capacity front end loader ranges between US$160,000 and US$180,000 and a heavy duty hell-boom loader ranges from US$225,000 to US$275,000. Under some circumstances, use of self-loading trucks may be the best solution.

Unlike loading which must be carried out at diverse locations in the forest, unloading is usually carried out at a permanent location - a log dump on a waterway, or at a mill yard, for example. One simple method is to use an A-frame and winch to parbuckle the logs from the truck. Another is to push them off using a mobile loader which can then distribute them to storage or to the mill. Very large loaders are available which can lift and carry an entire truckload. Paving the logyard greatly helps the unloading and storage operation.

Railway cars and barges are usually loaded by mobile loaders operating in a storage yard. However, in some developing countries fixed derricks are still in use for loading small quantities.

<u>Workshops and warehouses</u>

As mechanization of logging increases, so does the need for workshops and skilled technicians to maintain and repair the equipment. A few fortunate loggers may operate in areas well supplied with commercial repair service facilities, but most loggers must supply their own. The more isolated the operation, the greater the need for self-sufficiency in maintenance facilities. In areas where communications are poor and transport is slow, loggers may find it advantageous to provide facilities even for major overhauls in their own workshops.

Similar considerations apply to warehouses and to stocking spare-parts, fuel and lubricants in an orderly manner. Provision for continuing supplies of spare-parts, fuel and lubricant and the foreign exchange to pay for them must be part of the original financial planning of the enterprise.

Failure to carry out adequate preventive maintenance and prompt repairs disrupts production schedules and increases production costs in many logging operations.

Supervision, control and training

The success of any enterprise depends very heavily on the manner in which it is supervised and controlled. In logging, because of the ever-changing working conditions, supervision and control may be even more important than in other enterprises. Sufficient specialists in forestry and engineering must be available to plan and carry out projects within their fields of responsibility. Thoroughly trained supervisors must be available for each phase of the operation. An accounting system must be in effect by which phase costs can be determined periodically and promptly and reported to appropriate levels of management for information and remedial action. The staff must be organized so that each individual's responsibilities are clear-cut and well-known. Finally, the operation must be under the control of a general manager who can coordinate the activities of the entire organization and relate them to those of any associated conversion plants.

All managers, supervisors, and specialists must be provided with sufficient staff, transport and office facilities to enable them to carry out their functions efficiently.

Throughout the industry, but particularly in the developing world, shortage of trained staff is a recurring problem. Consequently, one of the prime responsibilities of the management and supervisory group is to provide training at all levels of employment. A well-organized training programme is essential if an enterprise is to be successful and continue to be successful.

2.4 Transportation methods

All logging, with the exception of tree felling and log-making, is concerned with materials handling and transportation. The logging systems previously discussed, generally covered the first movement of the logs from the stump to the assembly area. Movement from the assembly area to the final destination - usually over a very much greater distance - remains to be considered. It should be noted, however, that there is not always a clear-cut distinction between primary and secondary transportation. For example, in some areas portable sawmills are moved into the forest so that logs can be skidded directly to the mill. In other areas, Nigeria for example, light lorries may be used to transport logs both from the stump to the main roads and over the main roads to the mill. For most logging operations, however, there is a distinct secondary transportation phase.

Three main possibilities are available for secondary transportation - truck, rail or water. Any of these, either alone or in combination one with another, may be appropriate to a particular operation.

2.4.1 Selection of the appropriate method

The very earliest method of moving logs was by water. Trees were chosen for felling by their proximity to waterways which could float them to the point where they would be used. When nearby trees were no longer available, various manual systems, such as rolling or sliding, were developed to move logs to the waterways, thus providing inexpensive logs in low wage areas. This system is still prevalent in some regions, the Amazon being one example. As regional demand for wood increased, animals - oxen, horses, elephants, buffalo, etc. - came into use to move logs over greater distances to waterways. Finally, with the development of modern railways and road transport vehicles, more and more forests became accessible and less dependence was placed on water. Today, even where water is the prime method of transport, its use is usually preceded by a truck haul.

Selection of the mode of transport is heavily dependent on the terrain, the availability of suitable waterways between forest and mill, and on the incidence of existing roads and railways and conditions governing their use.

At one time, railroads were constructed for the sole purpose of moving logs, usually from landing to water, but the greater flexibility of roads and trucks has almost eliminated logging railways. Today, movement of logs by rail is generally confined to the use of public carriers where direct trucking costs are higher than the combined costs of a truck/rail movement. Similarly, water is used where combined truck/water costs are lower. Wherever forests are separated from conversion plants by large bodies of water, some form of water transport must form part of the transportation chain.

Distances covered in the secondary transportation phase vary considerably For the most part, truck hauls probably vary up to about 150 to 200 km though much longer hauls do occur. Hauls of up to 500 km occur in parts of Asia and even longer hauls - 3,000 to 4,000 km - have been noted for selected logs in Brazil. Rail hauls can reach 1,000 to 1,200 km. Water movements also cover great distances. On the western coast of Canada, barge hauls of over 500 km are common. In Brazil, logs are moved 1 000 to 1 200 km on the Amazon. In India, ocean-going vessels transport logs from the Andaman Islands to the mainland, a distance of about 1,200 km.

Cost comparison between the three modes is difficult as costs vary greatly with local circumstances. For long distances, water is usually cheaper than rail and rail is usually cheaper than truck, wherever waterways or railroads are available for use. One estimate has expressed the general cost ratios as 1.0 to 1.5 for water; 1.5 to 2.5 for common carrier rail, and 3.5 to 5.0 for truck. The primacy of trucking is due to the fact that there is seldom an acceptable alternative.

2.4.2 Trucks

Trucks used in logging cover a very wide range in power capacity and durability. Selection of the appropriate truck depends on local circumstances. Ground conditions for road building, weight of logs, quality of roads, and regulations governing the use of public roads all enter the selection. For example, in western North America very powerful, heavily built trucks and trailers with capacities to 75 m^3 are used on roads specially built for logging. However, in the same region where part of the haul is over public roads where load restrictions are in force, lighter trucks and trailers with capacities to 35 m^3 are used. Trucks of both types are used in some developing countries. Alternatively, in both developed and developing countries much lighter trucks are used without trailers for short log transport because they are readily available and meet local road standards. The types of trucks which are used for other purposes or the types which are available for hire can have a strong bearing on selection for logging use.

Costs range from US$ 100,000 - US$200,000 for heavy duty trucks and trailers to US$35,000 - US$45,000 for standard road vehicles.

2.4.3 Railroads

Construction and use of railroads exclusively for logging has been almost eliminated by the greater flexibility which can be obtained by using trucks. However, common carrier railroads continue to be used.

In some areas logging operations are carried out in remote forests served by a railroad but not by a public road system. In others, the haul distance from the forest to the conversion plant is such that rail costs offer an advantage over a truck haul. In these instances, logs are usually trucked to a storage yard equipped with a loading spur and operated by the logger. Railway carriages specially designed for logs - flat cars, skeleton cars and bulkhead cars - may be supplied either by the railway or by the logger. Usually, logs must be loaded in accordance with detailed regulations which slow the loading process.

Where an option exists, considerable care should be exercised in making a selection between a direct truck movement and one which involves both truck and rail. The costs of the rail movement include not only the charges made by the railway company but also the costs of storing and loading logs. Frequency of rail service and availability of suitable equipment must be included in the comparison. On the other hand, capital savings on trucks and the value of a buffer storage area also have a bearing. Energy costs may favour railroads in the future.

2.4.4 Water

Wherever it can be used effectively, water is one of the most economical methods of transporting logs. Common methods include floating logs in controlled groups on rivers, using either river currents or manpower to move them; towing rafts of individual logs or bundles of logs by tugs; pushing or pulling barges by tugs; and using coastal or deep sea vessels, usually loaded both in the hold and on the deck.

Water transportation of logs has always been imported in the tropics. As with all phases of forest harvesting, local conditions determine the selected method. In the Amazon drainage logs are floated on the great rivers there; lighter logs are bundled or rafted with heavier logs to keep them from sinking. In Burma, teak is floated to market but heavier hardwoods are railed. In the Andaman Islands, logs are rafted to assembly points and then loaded onto commercial vessels for transport to the Indian mainland. The cost of this 1,200 km movement was US$11/m^3 in 1977. In Indonesia, much of the inter-island log transportation is carried out by sailing boats. In the Philippines, similar movements are carried out using surplus military landing craft and commercial coastal steamers.

Water transportation is also used extensively in the temperate countries. Rafting on inland waters is an important movement in Finland. On the west coast of Canada, flat rafts and bundle rafts under tow have been the main form of log transport until recently. More recently, self-loading/ self-dumping barges have been introduced to decrease log losses and improve environmental conditions. The most recently constructed barge can carry 13,500 tonnes and is equipped with cranes to accomodate 45-ton log bundles. The twin-engined tug for use with this barge can develop about 4,600 kW. This equipment is used on the partially unprotected coast with hauls of up to 500 km. Cost is reported to be US$5 to US$6/m^3.

2.5 Constraints to efficient harvesting and development

The constraints to efficient harvesting and to the development of the forest industry can take many forms, varying with the nature of the forests and terrain and the stage of development of the society with which the forests are associated. The constraints may be natural, technical, financial, institutional or social. The following discussion outlines the major constraints which are frequently met with in developing countries. Obviously, the situation varies from country to country and seldom, if ever, are all of the constraints found in one country.

2.5.1 Natural constraints

The first of the natural constraints is the forest itself. To a very large degree, the forests of the developing countries are tropical forests containing a multitude of hardwood species. By contrast, many of the forests of the developed world are predominantly softwood and usually have very few species. These different types of forest require different silvicultural treatments. Quite frequently, softwood forests can be harvested by clear cutting. This treatment gives a high volume of harvest per hectare. Tropical forests, on the other hand, should be harvested by selective cutting. Further, in tropical forests market acceptance is usually limited to a few of the many species so that markets reinforce silviculture in limiting harvests to a low yield per hectare. Consequently, in developing countries, the volume per unit area which is available to support development costs is usually much lower than that in the developed world. This disadvantage is sometimes offset by high values for some of the hardwood logs, but lack of adequate markets continues to be one of the major problems in developing countries.

Terrain conditions in forests of the developing world are very diverse, ranging from deep swamps to steep mountain slopes. Similar ranges are also found in the developed world although the incidence of swamp forests and swamp logging is probably much lower. In both developing and developed countries, the effect of terrain in relation to available timber volumes (and values) must be carefully considered in selecting logging systems and planning logging operations. In both, difficult terrain is a serious constraint on harvesting forests which would otherwise be loggable.

Climate can also be a constraint on harvesting. In the temperate zones, the climatic problem is usually with cold and snow. In some regions, harvesting is most efficiently carried out in the winter on frozen ground, in others, deep snow in the winter limits logging to the snow-free months. In most developing countries the climatic problem is more concerned with rain and heat. In many tropical forests the ground becomes too wet for efficient logging during the rainy season, so that harvesting is restricted to the dry season. In addition, extreme heat may seriously affect labor productivity in the tropics.

Location, too, can be a problem in the developing world. Distances from sources of supply and available markets can both reduce the returns from the sale of the product and increase the costs of production. Costs can increase rapidly when production time is lost, because spare parts and replacement equipment must be obtained from distant places. Labor recruitment can be difficult for forest operations remote from centres of population.

Finally, although not truly a natural condition, infrastructure must be considered. In the forest regions of many developing countries inadequate roads, railways, shipping facilities, supply and servic organizations, housing and amenities place a severe constraint on forest industrial development.

2.5.2 Technical constraints

Many technical constraints on efficient harvesting can be found in developing countries. Probably the most important is an extreme shortage of trained, experienced managers and planners. From this lack spring many of tr other constraints - lack of adequate planning, lack of adequate cost/benef analysis, and lack of suitable cost control systems. In some regions ther even a complete unawareness of the need for detailed planning. Small intermittent enterprises, which use simple systems and not much equipment and which have low labour costs, can be reasonably successful with little detailed planning. As operations become larger and systems more complex, detailed planning and complete control become essential. Each phase - road building, felling, skidding, loading and transport - must be planned and coordinated with all other phases and with the needs of the conversion plant or market to obtain overall efficiency.

Many other problems, frequently considered to be constraints in themselves, can be traced to the shortage of trained managers. Deficient or non-existent workshops, lack of maintenance of equipment, failure to replace old and outdated equipment, and the purchase and use of inappropriate equipment can frequently be caused, at least in part, by inexperience on the part of senior management. Even long delays in repairing equipment can sometimes be traced to failure on the part of management to predict and supply spare-parts needs. Of course, poor management is not the single cause of these problems. Under-funding is an equally likely cause.

The next most important technical constraint is the lack of experienced supervisors, trained loggers and equipment operators, and qualified repair men. Even with the best planning and management, production targets cannot be met until these key people have been trained. In some regions, shortage of any manpower, trained or untrained, is a problem.

Training at all levels from senior managers to operators in the field must be a prime consideration in the search for more efficient forest harvesting in developing countries throughout the world.

Problems may develop through inadequate forest inventories. Although overall volume estimates may be quite accurate, estimates for each species are much less accurate. This limitation becomes important when logging is limited to a few of the many species in a tropical forest.

Short-term tenures may also inhibit development. Where tenures are short and future supply is uncertain, investors may be reluctant to make adequate investments in the enterprise.

Finally, in most active forest regions in developed countries, many logging operations exist, so each can learn from the successes and failures of the others. This is not always the case in developing countries. Frequently, a logging operation will develop in isolation and will have no opportunity to learn from others. Consequently, unless arrangements are made for familiarization tours of other forest regions, progress may be slow. It may also be hindered by lack of industry-oriented research.

2.5.3 Financial constraints

One of the most common forest problems in developing countries, as elsewhere, is the logging operation which has insufficient capital. Shortage of funds can lead to many of the same problems as poor management - deficient workshops and warehouses, lack of maintenance, failure to replace old and out-dated equipment. Such operations must receive additional financing if the operation is to become efficient.

Financial problems other than under-financing are usually concerned with foreign exchange. Few developing countries produce equipment covering the full range of logging needs and in many countries all logging equipment, as well as fuel and lubricants, must be imported. Suitable imported equipment is usually very expensive. Spare parts, fuel and lubricants, and replacement equipment require foreign exchange on a continuing basis. Inability or reluctance to supply adequate foreign exchange is a decided constraint on efficient harvesting in many countries. In terms of local funds, capital and operating costs are frequently increased by duties and taxes on imported equipment and spare parts.

Further financial problems can be caused by fluctuating prices for logs and forest products. Operations which are reasonably profitable at the high points of the price cycle can become losers and incapable of sustaining themselves at the low points.

2.5.4 Institutional constraints

A number of institutional constraints on forest development can be found in many countries. The following is a list which may not be complete.

- Lack of adequate policies and legislation covering land and forest use.

- Lack of a strong regulatory authority to enforce legislation and regulations and to encourage forest development.

- Conversely, a regulatory authority more disposed to conserve than use the forest.

- Inappropriate policies with regard to forest concessions.

- A slow-moving bureaucracy which impedes prompt resolution of resource use problems.

- Policies on imports which seriously delay acquisition and delivery of spare parts and replacement equipment.

- Forest fees levied by more than one level of government.

Forest development in one country may also be impeded by policies of another. For example, a market country may have policies which favour the import of logs over the import of manufactured products.

2.5.5 Social pressures

Forests throughout the world are subject to pressures which in some cases tend to limit industrial use and in others to destroy the forest itself. In the developed countries, some forests are being removed from industrial use as parks, game reserves and wilderness areas. At the same time, other forests are being destroyed to make way for expanding cities and towns, highways and roads, hydro-electric reservoirs and transmission lines, and all the paraphernalia of modern civilization. Similar activities are also taking place in developing countries, but here the major pressure comes from shifting agriculture in the tropics. In addition, the need for wood as fuel may limit the supply for industrial use in some regions. In others, cultural values such as certain species having religious significance, may also limit the availability of industrial wood.

2.6 Log production costs

Contrary to common misconception, logs are a commodity, whether produced for sale on an open market or by the logging arm of a sawmill. Logging in itself is an industry and in many parts of the world a separate entity, not part of an integrated industry. Therefore, logs, as any other commodity or product, must be prepared in such a manner as to meet the needs of the market place. At the same time they must be competitively priced. Thus, loggers must know their production costs and users must know what they can pay for the logs and still turn a profit. The cost and availability of logs to be used as the raw material in an industry, is a very important factor which, to the sorrow of many a failed industry, has to be considered carefully.

The importance of the cost of logs as a raw material in the production process can be seen by an examination of evaluations made for proposed industries. However, figures from actual situations, as reported by operating companies, indicate that pulpwood makes up some 40 per cent of the total cost of a ton of pulp and that sawlogs represent some 50 to 60 per cent of the cost of sawn timber. According to a recent report from Scandinavia the share of log costs in the total production costs even exceeds this figure. This illustrates the level of importance of log costs in relation to total production costs for both, pulp and sawn timber. There may be variations, both up and down, in developing countries.

These figures indicate real areas for cost savings in primary forest industries if producers are willing to put more effort into their harvesting operations.

An accurate knowledge of costs of raw material is also essential for any appraisal, evaluation, pre-feasibility or feasibility study into the viability of forest industries. Since the cost of raw materials is a major item of cost of production in forest industries, detailed log cost studies are normally carried out for any industrial proposal. These studies have been and are carried out in most areas of the world, but the importance of this problem area is often not recognized, which results in superficial studies, ignoring the vital effect of the share of raw material cost on the industry.

Due to the many different conditions and situations with which forestry and logging operations are faced, uniform costs cannot exist either for a specific region or even for similar forest types. The main factors which affect logging productivity and costs, in addition to the logging techniques, are such items as forest types (species, volumes per area unit, sizes of logs), terrain, climate, experience of personnel and social or cultural traditions.

Because of the multiplicity of factors to be faced, it is not possible to develop general logging costs on a worldwide or even regional basis, however, an attempt has been made to provide two examples which may give representative illustrations for cost structures and cost level estimates for the type of forest operations and regions as specified.

The first example shows the costs for a typical highly mechanized logging operation producing veneer logs and saw logs in a natural tropical high forest in the Far East where selective cutting is applied. The second example deals with pulpwood logging based on a clearfelling operation in man-made plantations in the African region. As stated earlier, there are great variations from area to area and operation to operation, so these figures may only be taken as an indication. Percentages by phases of the operation are also given, which indicate the relative importance of each.

Example No. 1: Logging costs in tropical high forests in the Far East region

Description of the forest conditions

This tropical high forest consists mainly of Dipterocarp species with an average extractable commercial wood volume varying between 50-80 m^3 per ha. The average usable wood volume of the dominant trees ranges from 5 to 10 m^3, with an average breast height diameter of 70-90 cm and a clear bole height of 15-20 m. Generally, these types of forests are to be found at elevations of from 400 to 700 m, where low bearing soils prevail. In some of the areas rock outcrops appear which, after blasting and crushing, can serve as road construction material. The climate can be characterized as humid-tropical, which implies high rainfall and high temperatures throughout the year.

Logging equipment and method

Due to the large sizes of logs, logging operations are highly mechanized. For felling and bucking of trees, as well as for the clearing of skid trails, one-man power saws are used whereas debarking of logs is done manually.

Ground skidding is carried out by the use of crawler tractors in combination with heavy duty articulated wheeled skidders. The average skidding distance varies between 300 and 500 m, corresponding to a road net density ranging from 12 m to 14 m per ha.

Loading and unloading is performed by front-end loaders mounted either on wheels or tracks equipped with log forks.

The average transport distance for trucking is 30 to 40 km. Transport from the log landings to the riverside is carried out by heavy duty trucks with pole-type trailers, though water transport, using rafting and towing by tug boat, is the major system.

	Logging costs as of beginning 1982	
	in US$/$m^3$	in percent
Activity		
Planning, surveying and engineering	0.70	1.8
Felling, bucking and debarking	2.20	5.5
Skidding	8.50	21.0
Loading, transport and unloading	9.30	23.0
Rafting/towing	4.00	9.9
Road construction and maintenance	5.30	13.1
Total operational costs (including depreciation)	30.00	74.3
Overhead, administration	10.40	25.7
Total costs, excluding royalties, taxes, fees and services	40.40	100.0

Example No. 2: Logging costs in plantation forests in the African region

Description of the forest conditions

Man-made forests of the species Gmelina arborea were established for use as a raw material for a pulpmill. Standing wood volumes vary, according to the age of the plantation, from 150 m^3 to 350 m^3 under bark, per ha. Tree sizes to be logged vary from 20 to 30 cm d.b.h. and it was estimated that some 3 per cent of delivered logs had butts greater than 60 cm is diameter. Average volume per tree is of the order of 1 m^3. The forests are located at an elevation of 100 m above sea level, in rolling terrain with slopes generally less than 20 per cent, reaching 40 per cent in some areas. Soils are sandy to clay loams, overlaying granite bedrock. Rain mainly occurs during May to October, however, at times the rains start in April and last until November. During these rainy periods accessibility to forests is extremely difficult. With regard to the road infrastructure within the forest area, a road net density of some 12 m per ha is the norm and the hauling distance to the mill ranges from 40 to 70 km.

Applied logging equipment and method

Since the tree volumes are comparatively smaller than those in natural forests, medium-sized logging machinery is utilized.

Clearing of shrubs is done manually, to allow easy access for the felling of trees. Trees are felled and delimbed by chainsaw. Skidding of tree-length logs is carried out over an average distance of 300 m by means of a farm tractor equipped with a forestry winch. Bucking of tree lengths is done at roadside by chainsaw. Piling of bucked logs and/or loading on to trucks is performed manually. The average truck load is in the order of 8 tons.

Logging costs as of beginning of 1982

Activity	In US$/m^3	In percent
Clearing	0.30	0.9
Felling, delimbing	2.70	8.0
Skidding	8.00	23.6
Bucking	1.20	3.5
Piling	1.00	3.0
Loading	2.00	5.9
Hauling	12.50	36.9
Road construction and maintenance	1.20	3.5
Total operational costs (including depreciation)	28.90	85.3
Overhead administration	5.00	14.7
Total costs excluding royalties, taxes, fees and services	33.90	100.0

SECTION 3: PRIMARY FOREST INDUSTRIES

3.1 Introduction

The mechanical processing of wood involves three categories of manufacturing; namely, sawnwood products such as unplaned and planed sawnwood and railroad ties; peeled and sliced wood products such as veneer and plywood; and reconstituted wood products such as fibre board and particle board.

The mechanical processing of wood is one of three major industrial wood utilization processes. The other two are the fuelwood and chemical processing industries. While this paper is concerned only with the mechanical processing component, it is important to recognize that these three industries are not unrelated. They compete for raw materials amd sometimes for markets.

The type of mechanical processing used to convert wood to commodities may be very simple or quite complex. Sawnwood and railroad ties may be produced by such primitive methods as hand hewing or pit sawing, or they may be the product of high speed, computer controlled precision sawmills. As tree values increase and tree quality decreases world-wide, the more sophisticated manufacturing facilities are assuming an increasingly important role, even in the developing countries where tree quantity and quality problems are not always as acute as they are in the industrialized countries.

For many countries of the developing world, wood is the natural resource easiest to exploit in world markets. In log form it is easy to harvest and to transport. Timber is the leading export commodity for Sabah and is second only to oil in Indonesia. For many other tropical countries the export of wood is the most important source of foreign exchange.

3.2 Consumption of mechanically processed wood

The driving force behind the production of forest products is demand in the market place. Mechanically processed wood is used primarily for building structures, either directly or indirectly, and is commonly used for the construction of houses and industrial and commercial buildings. Mechanically processed wood is incorporated into the structures as stressed components, skin components or decorative components.

Coniferous wood has physical properties that make it suitable for load bearing components, such as columns and beams and it is used as scaffolding and as shuttering for concrete during building construction. It is also used throughout the world for panelling, flooring, ceilings, and for furniture and fixtures for use in the buildings. Non-coniferous species are the major wood for home and institutional wood furniture and are also used for panelling, ceilings and flooring.

Wood has been a very important building material in the industrialized world for a long time. The insulating properties of wood make it suitable for use in buildings where conservation of heat is important, and the climatic conditions that encourage the use of wood as a structural building component exist in the temperate zone countries. Here too are located the major sources of coniferous wood. Not surprisingly, it is in the industrialized countries of the temperate zones where there is much demand for mechanically processed wood for use in building construction.

In addition to its use in buildings, mechanically processed wood is also widely used in the transport industry for railroad ties, boxes and crates, pallets and dunnage.

At a time when energy costs are increasing, mechanically processed wood has an advantage over its non-renewable competitors with respect to the energy required for its manufacture. A study conducted by the U.S. National Academy of Sciences (1976), gave the following comparisons between processing energy required to fabricate softwood lumber structural components and that required for comparable components produced from competitive materials.

Floor joints:	wood x 50 = steel
Exterior wall framing:	wood x 20 = aluminium
	wood x 14 = steel
Interior walls - studs:	wood x 12 = aluminium
	wood x 8 = steel

Wood roof trusses	wood x 7 = steel (rafters)
Siding:	wood x 5 = aluminium
	aluminium x 5 = brick
	wood x 25 = brick

The explanation of this energy conservation phenomenon is that a substantial part of the energy required to produce a wooden structural component is provided by the photosynthetic process. Relatively little additional work needs to be done on the tree stem to produce the component.

Table 3.1[1/] shows the apparent consumption of mechanically processed wood by regions for the years 1970 and 1980. World consumption of all mechanically processed wood increased by 8.9 per cent from 1970 to 1980 and, except for Oceania and the U.S.S.R., every region recorded an increase over this period.

In each of the two years studied, more than 90 per cent of the demand for mechanically processed wood was in the temperate regions. While the Asian region includes both temperate and tropical areas, it is industrialized Japan that consumes most in this area.

3.2.1 Sawnwood

Sawnwood includes unplaned and planed sawnwood and railway sleepers. It is manufactured in sawmills and planing mills using both conifer and non-conifer species. The conifer and non-conifer components of the industry are generally quite distinct and it is rare for any one sawmill to manufacture both conifer and non-conifer sawnwood products.

Conifer sawnwood

Table 3.2 indicates the apparent consumption of conifer sawnwood, by regions, for the years 1970 and 1980 excluding railway sleepers. World-wide

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1/ All table are in the Annex.

consumption of conifer sawnwood increased by 2.0 per cent during the nineteen seventies but this was substantially less than the 8.9 per cent increase over the same period for mechanically processed wood as a whole. Since conifer sawnwood has the largest volume consumption among the mechanically processed wood commodities, the modest percentage increase still represents a significant volume.

Tables 3.3 and 3.4 indicate the ten countries that were principal consumers of conifer sawnwood in 1970 and 1980 respectively. The top ten consumers of conifer sawnwood accounted for about 82 per cent of world demand in 1970 and about 80 per cent in 1980. The identity of the top ten consumers changed very little over the ten years. While the order within the top ten varied somewhat, nine of the ten in 1980 were identical with the listing in 1970. The exception was Poland which was replaced by Finland.

It seems unlikely that the pattern of consumption of conifer sawnwood will change dramatically during the decade of the eighties from that exhibited during the previous decade. The absolute level of consumption is likely to be responsive to the general health of the world economy, which has been poor during the first two years of the present decade.

In reporting on U.S. Forest Service (U.S.F.S.) projections, Darr (Sedjo, 1981) note that "U.S. consumption of softwood lumber generally follows the track of housing starts". The U.S.F.S. projections are for consumption of softwood (conifer) sawnwood to reach 81.26 million m^3 in the U.S.A. by 1990. This would represent an increase of 7.2 per cent and would compare with an increase of less than 0.2 per cent during the 1970s. Not all U.S. authorities agree with the U.S.F.S. projections. Zivnuska (Sedjo, 1981) questions the validity of the projection model used and suggests that the projected consumption of softwood lumber is far too high. He proposes that with a more eoconomically realistic projection model "..... softwood lumber consumption in 2 000 would be projected at slightly more than 40 billion board feet[2/] rather than 48 billion board feet[3/] as now shown." Ward, who is

2/ 94 million m^3
3/ 113 million m^3

also critical of U.S.F.S. projection methods (Sedjo, 1981), suggests that for the U.S.A. "domestic demand for softwood lumber between 1980 and 1990 may grow faster than both world and world import demand; however, between 1990 and 2000, world demand growth could be five times, and world import demand ten times greater than domestic growth".

The Timber Committee of the U.N. Economic Commission for Europe (ECE/FAO, 1982) is pessimistic about the short-term outlook for consumption of sawn softwood. It states in the 1982 Annual Forest Products Market Review that "The markets for sawn softwood in 1981 developed largely under the influence of the economic downturn, which set in, in Western Europe, in the second half of 1980 and worsened thereafter".

The Timber Bulletin for Europe in its report in a "Medium-term Survey of Trends in the Sawnwood and Sawlog Sector" (ECE/FAO, 1981) states with respect to 1979-81 that:

> "Building activity was strongly affected by these recessionary trends, and this was reflected in the consumption of sawnwood, particularly of sawn softwood. Building construction, notably housing, is the most important outlet in the majority of countries in the region for this product".

Apparent consumption of conifer sawnwood in the USSR, while very large, nonetheless declined between 1970 and 1980 by about 14 per cent. For Japan the apparent consumption of conifer sawnwood remained fairly stable over the decade of the seventies.

Non-conifer sawnwood

Non-conifer sawnwood is used in the building construction industry primarily in non-stressed building components. It is widely used for flooring, wall panelling, doors, cabinets and fixtures. Non-conifer sawnwood is also extensively used in the manufacture of household and institutional furniture. In some part of the world, notably North America, it is used in large and growing volume for pallets. Table 3.5 shows the apparent consumption of non-conifer sawnwood by region for the years 1970 and 1980. For the world as a whole the consumption of non-conifer sawnwood increased by something over 11 per cent from 1970 to 1980. This is a substantially greater growth than occurred in the conifer sawnwood sector but it started from a much smaller base. Nonetheless, of the total world consumption of sawnwood the non-conifer component increased from 22.8 per cent to 24.4 per cent over the decade of the seventies. The ten countries that were the principal consumers of non-conifer sawnwood in 1970 and 1980 are listed in Tables 3.6 and 3.7 respectively. In 1970 about 69 per cent of world consumption of non-conifer sawnwood was represented by the top ten consumers. In 1980 the percentage attributable to the top ten consumers was 64 per cent. These percentages are substantially less than the comparable data for conifer sawnwood, indicating that consumption of non-conifer sawnwood is more dispersed among countries. Non-conifer forests are, of course, more widely distributed geographically than are conifer forests.

As was the case for conifer sawnwood, the make-up of the top ten consuming countries was quite stable. Nine of the ten leaders in 1970 were also on the list in 1980. Australia was replaced by Nigeria.

Comparing the consumption of non-conifer sawnwood in 1970 with 1980, the medium-term Survey of Trends in the Sawnwood and Sawlog Sector (ECE/FAO, 1981) noted:

> "During that period apparent consumption of sawn hardwood grew relatively steadily in Europe, and more strongly than sawn softwood; in North America it practically stagnated, with considerable fluctuations and declined somewhat in the USSR. For the ECE region as a whole, the overall trend was thus a modest overall increase in apparent consumption of sawn hardwood."

The projections of the U.S. Forest Service of consumption of hardwood lumber are discussed by Darr (Sedjo, 1981) as follows:

> Of the solid timber products - logs - lumber and plywood - production of and trade in hardwood lumber are probably the most difficult to project.

The projections indicate rapidly expanding domestic demands for pallets and other end-products that can use hardwoods and do not have lumber quality as a key criterion."

Consumption of non-conifer sawnwood by South American countries increased by about 62 per cent during the decade of the seventies. The principal consumer among the South American countries was Brazil. The increase in consumption of non-conifer sawnwood in Africa was a spectacular 116 per cent though it was on a relatively modest 1970 base.

3.2.2 Market veneer

Market veneer includes all veneer peeled, sliced or sawn that is marketed in veneer sheet form and not further processed into product. It covers a wide variety of products, from the very high priced thin sliced face veneers produced from prime woods, to low quality rotary veneers manufactured for use in the production of baskets and hampers. Because these varied products are combined in the FAO data base, it is impossible to deal with them separately. Table 3.8 indicates the apparent consumption of market veneer by regions for the years 1970 and 1980. The total production is small compared to other mechanically processed wood commodities. World consumption inccreased by about 52 per cent in ten years, from 3.3 million m^3 to 5.1 million m^3. Europe is the largest consumer of market veneer accounting for about 48 per cent in 1970 and 43 per cent in 1980.

3.2.3 Plywood

Plywood includes a variety of panel products incorporating a veneer crossbanded construction. It may be all veneer, or a combination of veneer outer plies with a core of solid wood, particle board or some other core material. Plywood data are agglomerated, though the generic term plywood includes a variety of products whose uses may be quite different. Plywood may be produced from conifer or non-conifer species and, occasionally from a mixture of the two. Sometimes conifer wood is used in lumber cores with non-conifer wood in the veneer cross banding and face and back. The U.S. conifer plywood industry sometimes applies a non-conifer face to a panel consisting of a conifer center, cross banding and back. In general, softwood plywood is used for structural purposes and hardwood plywood for decorative purposes, though there are many exceptions to this rule. Some plywood is manufactured to standard sizes, thicknesses and constructions and sold as stock commodity items, while other plywood is custom built to size, thickness and construction to meet the needs of the consumer.

Table 3.9 indicates the apparent consumption of plywood by regions for the years 1970 and 1980. Worldwide plywood consumption has increased over 17 per cent in the period 1970 to 1980.

Tables 3.10 and 3.11 show the ten countries that were principal consumers of plywood for the years 1970 and 1980 respectively. The ten largest consumers of plywood accounted for about 86 per cent of world consumption in 1970 and about 83 per cent in 1980. Eight of the first ten consumers in 1970 repeated this in 1980. Whereas the U.S.A. was the dominant consumer in both years, accounting for 47 per cent and 43 per cent respectively of world demand, the most spectacular growth was provided by the second largest consumer, Japan. That country increased its plywood consumption from 6.9 million m^3 in 1970 to 8.4 million m^3 in 1980, a growth of over 22 per cent.

Latin America, Africa and Oceania had very little demand for plywood. All other regions showed a large and growing consumption, except a small decline in the USSR.

2.4 Particle board

Particle board is a generic term which includes a variety of wood panel products made of small fragments of wood such as chips, flakes, splinters, etc., bonded together with an adhesive. Among the mechanically processed wood products, particle board is of the most recent origin, having appeared on the world scene since World War II. The World Consultation on Wood-Based Panels (FAO, 1976) described the history of the development of particle board as follows:

"Production of particle board was practically non-existent in 1950, but by 1960 it had become established in all regions, although European output dominated with 72 per cent of production. In the next decade all regions showed high rates of expansion, with world output increasing by 500 per cent. The European industry still dominated, but North America and the USSR had, by 1970, achieved substantial production. In the first years of the 1970s European industry continued to expand at quite a rapio rate, an average annual increase of more than 2 million m^3 with major expansion in the Federal Republic of Germany, Belgium and France. However, it is interesting to note that Northern American and Japanese growth accelerated, while in most of the rest of the world growth declined to lower, but still substantial rates of expansion. The USSR production has increased in absolute quantities rapidly since the mid-1980s. It appears that the particle board industry is still largely an industry of industrialized countries at higher income levels, despite its early initial establishment in all regions."

Table 3.12 shows the apparent consumption of particle board by regions for the years 1970 and 1980. It is interesting to note that while Europe, North America and the USSR still represent the overwhelming share of particle board consumption in 1980 (approximately 92 per cent) the largest rate of growth of consumption between 1970 and 1980 occured in Latin America and Asia.

Tables 3.13 and 3.14 show the largest consumers of particle board in 1970 and 1980. In 1970, the ten largest consumers accounted for 72 per cent of world consumption and in 1980 for 67 per cent. In 1970 the top ten consumers represented only Europe, U.S.A. and USSR. In 1980, Japan and Canada had entered the list of top ten consumers, further indicating a broadening of the consumption base.

Particle board is a direct competitor of plywood in many uses and is often sought as a substitute on the basis of its lower cost. It is likely to be in greater demand as a plywood substitute, as veneer logs become increasingly scarce and more expensive. It is also likely to find greater demand as a core material for veneer faced panels. The latest development in the particle board field is structural particle board. This product is a competitor of structural softwood plywood and is likely to experience a rapidly growing consumer acceptance.

2.5 Fibreboard

Fibreboard differs from particle board primarily in the nature of the basic particle used in its manufacture. Where the basic particle is essentially the wood fibre, or small bundles of fibres, the product is fibreboard. Where the basic particle is a chip, flake or sliver the product is particle board.

Fibreboard, as a panel product, is classified according to its density or its method of manufacture. The fibreboard industry originated in the 1920's, but experienced its most rapid growth during the past thirty years. The original fibreboard was a high density wet process board. A wet pulp mat was formed and pressed in a hot press to a density in the range of 0.8 to 1.2 grams per cm^3. Later, dry processes were developed which differed from the wet process in that the pulp mat was formed and conveyed to the press on air rather than water.

Low density insulating boards have been manufactured and used extensively in North America. These boards are compressed in manufacture to densities in the range of 0.15 to 0.4 grams per cm^3.

During the past fifteen years or so, medium density fibreboards have been developed and manufactured. These grades are produced in the density range of 0.4 to 0.8 grams per cm^3.

The principal fibreboard consuming regions, see Table 3.15, have been North America and Europe, followed by the USSR and Asia. In the decade between 1970 and 1980, world consumption of fibreboard increased by about 14.5 per cent. Consumption in North America declined by 8 per cent while European consumption increased by 10 per cent. The greatest growth in fibreboard consumption during this decade was among the second level consumers. Asia, primarily Japan, increased its consumption by 21 per cent and the USSR by as much as 122 per cent.

In 1970 the ten countries that were the largest consumers of fibreboard as shown in Table 3.16, accounted for 79 per cent of world consumption. With the exception of Japan and Brazil, these countries were all European or North American. The United States was the largest consumer by a very great margin. Ten years later in 1980, nine of the top ten consumer countries (Table 3.17) were the same as in 1970; only the Netherlands had been replaced by China. The use of fibreboard has increased rapidly in developing countries, but it still represents a very modest share of world consumption. According to the World Consultation on Wood-Based Panels FAO, 1976:

> "Although consumption of fibreboard has grown at rapid rates in Japan and the USSR, North America and Europe continue to be the dominating consumers of fibreboard both on a total and per capita basis. Non-compressed fibreboard (insulation board) continues to be largely a North American product with a consumption rate of more than 7 tons per 1000 capita; consumption rates in Europe, Japan and USSR only approach 1 ton per 1000 capita.....On a volume basis fibreboard of all types combined, is still more important than particle board in North America and Japan but in Europe fibreboard has an inferior position by far. Only Sweden and Norway are notable exceptions to the general European pattern."

3.3. Production of mechanically processed wood

Mechanically processed wood products are the most demanding forest products in terms of the size and quality of raw material required in their manufacture and sometimes these mechanically processed products are the only output of a forest utilization system. When this is the case, there can be a very large residue of non-commercial and un-merchantable trees or unused portions of harvested trees in the forest, and substantial unused portions of logs following manufacture.

As an example, in a natural all-aged, mixed species hardwood tropical forest producing a single commodity, non-conifer sawnwood, the output of sawnwood can be only 10 per cent of the total biomass of the stand, depending upon the number of species acceptable in the sawnwood market. Such a forest utilization system would be much more efficient in terms of raw material yield if the forest was matched with a number of manufacturing and marketing components, thus providing a higher yield from the forest resource and an opportunity to spread the manufacturing and marketing overhead over more units of output. While this paper is concerned only with mechanically processed wood, it must be recognized that usually its production can not be separated from complementary industries that can utilize those portions of the forest biomass which are not suitable for the production of such premium primary products as sawnwood and plywood. Among the mechanically processed wood products, particle board and fibreboard are commodities that are relatively indiscriminate with respect to size and quality of the raw material, and thus can complement sawnwood and plywood. Products in other sectors that can serve the same role are fuel and pulp.

The production of mechanically processed forest products is normally very closely linked geographically to the consumption of those products. The countries that generate demand for a product tend to produce it to meet that demand provided they have the raw material resources that make this possible. Since forests are so widely dispersed geographically, most countries have the resources to meet a reasonable proportion of their requirements for mechanically processed wood.

Tables 3.18 to 3.35[4/] are the production counterparts of consumption tables 3.1 to 3.17. Comparing the lists of largest consumers with those of the largest producers of mechanically processed commodities for 1980, the uniformity is striking. For conifer sawnwood, nine of the ten top consuming countries were also among the ten top producers. In the case of non-conifer sawnwood, the ratio was 7 to 10, for market veneer it was 9 to 10, for plywood 7 to 10, for particle board 7 to 10 and for fibreboard 8 to 10.

While the industrial countries are among the leading consumers and producers of mechanically processed wood at this time, the developing countries of the tropics are increasingly appearing in positions of prominence in these tabulations. Brazil was among the ten largest consumers of

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4/ All production figures for sawnwood in these tables exclude railway sleepers.

non-conifer sawnwood in 1970 and 1980 and was also among the ten largest producers of this commodity in the latter year. It consumed 96 per cent of its production of non-conifer sawnwood in 1970 and 98 per cent in 1980. Nigeria, another tropical country among the ten largest consumers and producers of non-coniferous sawnwood, consumed all of its production internally. Indonesia, a nation that is substantially involved in world trade in non-conifer sawnwood, nonetheless consumed 65 per cent of its production 1980.

The pattern of production of plywood in Southeast Asia may change during the decade of the 1980s. Republic of Korea and China have been among the ten leading plywood producers throughout the decade. They have also been significant consumers of plywood during this period. China in 1970 and Republic of Korea in 1980 were among the ten largest consumers of plywood. The producing countries of Republic of Korea, China and Singapore have production facilities based upon imported logs. They do not have an indigenous raw material supply. It is possible that in the next decade Indonesia and Malaysia may assume the production roles filled so far by Republic of Korea, China and Singapore.

The production of particle board was dominated by North America and Europe. In 1970 and in 1980 the ten leading producer regions were North America, Europe and the USSR. Throughout the decade the leading producer was the Federal Republic of Germany, closely followed by the United States. Over the course of the decade, production of particle board more than doubled worldwide. Particle board has the advantage that, compared to lumber and plywood, it is relatively indiscriminate with respect to quality of raw material.

The production of fibreboard is somewhat more gregarious than the production of particle board. While North America, USSR and Europe dominate the production of fibreboard, Asia and Latin America are also represented among the major producers. Japan was an important producer throughout the decade and Brazil and China joined the ranks of the ten largest producers in 1980.

3.4. International trade in mechanically processed wood

Trade in forest products between countries and regions is complex. It tends to be based first of all upon a country's forest resources, and upon the way in which those resources are used to meet the country's own demand for forest products. Imports reflect the need to augment supply where deficits exist, while exports are the response to the development of surpluses. A second major factor in world trade in wood is a country's desire for a product which it cannot produce, or at least cannot produce in quantity. An industrial temperate country's demand for exotic decorative hardwoods which can only be obtained from developing countries of the tropics is a case in point. A similar case would be a tropical country's need for high strength long fibred paper that can be produced only from coniferous wood.

In discussing international trade in forest products, Sedjo and Radcliffe (1981) state:

> "The world's forest products trade has many dimensions. Total trade and the rate of increase in trade are important, but also are the distribution of forest resources, the commodity composition of forest trade, the existing interregional structure of forest trade, flows, and recent changes in that structure."

A strong intra-country and intra-regional trade in wood has always been a solid basis for engaging in world-wide inter-regional trade.

Table 3.36 indicates the trade in mechanically processed wood by regions for 1970 and 1980. In both years the major movement of wood in international trade was in North America and Europe, with a much smaller but still significant movement in Asia. The nature of this trade can be better examined in terms of specific commodities.

3.4.1 Conifer sawnwood

Table 3.37 shows the world trade in conifer sawnwood for the years being examined. In both 1970 and 1980 the major trading regions were North America and Europe. Table 3.38 shows the principal trading countries in conifer sawnwood for 1980. Much of the trade in both Europe and North America in 1980 was intra-regional. In North America, Canada provided about 20 per cent of the USA requirements for cohifer sawnwood, while in Europe, the Nordic countries and USSR exported conifer sawnwood in large volumes to western and eastern Europe. There was a smaller but significant flow of conifer sawnwood from North America to Europe and also to Japan.

3.4.2 Non-conifer sawnwood

Table 3.39 shows the trade in non-conifer sawnwood for 1970 and 1980. The major trade flow in non-conifer sawnwood in 1970 was within Europe. In 1980 this intra-regional flow was still important but a second major intra-regional flow developed in Asia. Asia also became the principal supplier of non-conifer sawnwood world-wide supplying significant quantities of this commodity to Europe and the United States. Singapore, with no resource base of its own, was an important factor in world trade in the non-conifer sawnwood originating in Asia. As noted in Table 3.40, Singapore was one of the leading world importers of non-conifer sawnwo d as well as an exporter of the same commodity.

3.4.3 Market veneer

The volume of world trade in market veneer was quite small compared to other mechanically processed wood commodities. Europe and North America were the most active trading regions in 1970, with Asia assuming an important trading role in 1980. The regional trade figures for 1970 and 1980 are given in Table 3.41 and the top ten countries trading in market veneer in 1980 are shown in Table 3.42.

3.4.4 Plywood

There are two types of plywood; conifer and non-conifer. The FAO data on consumption, production and trade do not distinguish between the two, and the trade data includes also blockboard. Conifer plywood is essentially a structural panel. Non-conifer plywood may be either structural or decorative, but it is generally sold as a decorative panel. Conifer plywood is produced almost entirely in North America, predominantly in the USA. Non-conifer plywood is produced in all regions of the world including the USA. Table 3.43 indicates the trade in plywood and blockboard among regions for 1970 and 1980. The major trading regions in 1980 were Europe, Asia and North America. Table 3.44 shows the principal plywood and blockboard trading countries in 1980. The USA is a major importer of non-conifer plywood from the Asian countries, though it exports softwood plywood to Europe. There is also a trade flow in non-conifer plywood from Asia to Europe and the Near East.

The Asian plywood industry represents one of the most expansive components of the forest products sector during the past thirty years. During the decade of the 1950s the Japanese developed a major plywood industry based upon logs purchased from the Philippines, Malaysia and Indonesia. The plywood was used to meet the needs of the domestic market, but was also exported to the U.S.A. in very large quantities, to meet the demand for stock panels in the post World War II home construction expansion. The Philippines also manufactured and shipped to the U.S.A. large quantities of non-conifer plywood for home construction purposes.

The plywood industry of Malaysia served the markets of the United Kingdom in a similar way. Mills in Singapore were active in the manufacture and sales of plywood to the United Kingdom and other parts of Europe. During the past 10 to 15 years, the Republic of Republic of Korea and China have become very aggresive in the plywood industry, based upon logs imported from the producer states (Philippines, Malaysia and Indonesia). Republic of Korea and China have encouraged the plywood industry and, as a consequence have some very modern factories.

Asia has become a major exporter of hardwood plywood to the industrial countries of the world. Within the region, Japan has been a very large consumer, but for the most part the tropical hardwood plywood of Asia has been exported to industrial countries in North America and Europe. The region as a whole is export dependent with respect to plywood and, with the exception of Japan, the Asian countries have very modest interral demands for the commodity. The forest utilization system which has produced tropical hardwood plywood in Asia, has extended across national boundaries for the most part. The logs have been supplied by the Philippines, Malaysia and Indonesia. The plywood manufacturers have been Japan, Singapore, China and Republic of Korea.

These are some of the major industrial centres in Asia with experience in manufacturing and they have an industrially experienced labour supply to call upon, plus a reservoir of industrially experienced managers.

Within the past few years a change has occurred in this system. The log suppliers have moved to restrict the export of logs and to insist that plywood be manufactured in the country of log source. Takeuchi (1982) suggests that the objectives of the log producing countries in pressing for in-country processing are:

- To conserve the semi-nonrenewable resources,
- To collect maximum resource rent from the rich forest resources which are owned by governments, and most important,
- To secure benefits from increased local processing of logs.

Whether this movement is in fact advantageous to the log producing countries will depend upon their abilities to manufacture plywood and sell it at a competitive price, and their abilities to retain and expand the markets served by the current plywood manufacturing countries.

The idea of manufacturing mechanically processed wood near the source of the logs is certainly not new and unique to this situation. There are apparent advantages and disadvantages associated with the movement. The principal advantage to processing near the source of logs is that it eliminates the need to transport a very heavy and bulky raw material long distances and so incur the costs of multiple handlings before initial manufacture. In the course of the initial veneer manufacture, the bark, round up, core and green clipping waste is removed and this may represent as much as 30 to 50 per cent of the original log volume. Furthermore, a high percentage of the original water is removed from the wood and this can often cut the weight of the wood in half. There may also be disadvantages to processing near the source of logs and these can offset the advantages. Among the potential disadvantages are:

- In remote rural areas there may be an inadequate labour supply and particularly a shortage of skilled labour. It may be difficult to attract competent technologists and managers to reside in remote areas.

- Unless there is a mix of integrated industries in the area, the opportunities to achieve full utilization of residues may be lacking. This will increase the cost of producing the plywood.

- Facilities for handling and shipping plywood may be inadequate, even though they were adequate for logs.

- Procurement of non-wood supplies, i.e. adhesives, sandpaper, tape, etc., may be difficult.

- Facilities for major maintenance of equipment may be inadequate or lacking.

Some of these apparent disadvantages may be offset if the factories are located in metropolitan centres, but then the advantages may also disappear.

As the log supplying countries assume the manufacturing role aggresively, they will presumably begin to dominate the major export markets for non-conifer plywood, namely the U.S.A. and Europe. Given the present state of the market in these countries, the demand is likely to be relatively low for some time and expectations in terms of meeting delivery schedules and quality standards are likely to reflect a buyers market. Nonetheless, the producer countries do control the major sources of plywood raw material in Asia. Papua New Guinea, Sabah and to a certain extent Sarawak, still make logs available for export to the Asian manufacturing centres (China, Republic of Korea, Singapore, Japan and Hong Kong).

3.4.5 Particle board

Just as Europe dominates the production and consumption of particle board, so too does it dominate world trade in this commodity. As will be noted in Table 3.45, it accounted for 84 per cent of world imports and 88 per cent of world exports in 1980. As indicated in Table 3.46, the U.S.A. was the only non-European country to appear among the top ten importers of particle board in 1980. The use of particle board, and accordingly its production, is growing very rapidly in North America, but the developing countries of Africa, Asia and Latin America have not been significant users, producers and traders of particle board.

3.4.6 Fibreboards

The pattern of world trade in fibreboard is similar to that of particle board, see Tables 3.47 and 3.48. Europe accounted for 75 per cent of world imports of fibreboard in 1980 and 61 per cent of world exports in the same year.

3.5. Opportunities for developing countries

As the developing countries of the tropics seek ways to utilize their natural resources to secure social advancement, those with large areas of forest turn to the forest resource as a logical candidate to support economic growth. This is particularly true of those countries of Africa, Asia and Latin America in the humid tropics, where natural forests, which appear very productive, are a major feature of the landscape. But this promise has not often materialized. The forests of the humid tropics are often very unproductive in terms of commercial and industrial products. Catinot (1972) noted with respect to such tropical forests:

> "as knowledge of these ecosystems advances, a certain disappointment is felt, so complicated is their study and so modest their wood production: 400 cubic meters per hectare of biological production and 5 to 10 cubic meters per hectare of economic production"

Bethel (1982) points out with respect to this same phenomenon, that natural forest stands in the humid tropics are generally all aged, multi-species stands and these stands are so diverse that the match achieved between the forest and the manufacturing and marketing systems available to it is typically very poor. The utilization efficiency that might be expected from a natural stand in the Atlantic lowlands of Costa Rica, if used as a supply base for the manufacture of lumber in a sawmill, is only 10 to 15 per cent. This reflects current sawmill practices and species acceptance in the area. The yield of product is of the same order as suggested by Catinot (1972). The utilization efficiency of this system could be improved by changing the character of the forest, which is what happens when a managed single species, even-aged plantation is substituted for a mixed species, all-aged natural stand. The utilization can also be improved by enlarging the mix of manufacturing facilities.

The easiest way to increase the productivity of tropical forests is to improved the yield of commodity recovered from the forests. This is also the best way to reduce the production costs of the commodities now being produced, since it permits spreading overheads across a much broader base. If developing countries are to be competitive with industrial countries in product yield they will have to develop a mix of integrated industries to utilize the wood from all-aged, multi-species forests. Usually this mix will include at least one industry that is relatively indiscriminate with respect to species, size and quality. The three principal candidates in this domain are generally pulp, particle board and fuel.

The manufacture of pulp is a very capital-intensive process. Hardwood, particularly mixed hardwoods, are not the preferred raw material supply, though pulp can certainly be manufactured from mixed hardwoods. Furthermore, even the smallest pulpmill is large compared to a sawmill or a plywood plant and sometimes its raw material demands are so great that it becomes the tail that wags the dog.

Particle board is produced very largely for domestic consumption throughout the world, and the small amount that is exported is traded among the consuming countries of Europe. As already noted the tropical countries have not been significant consumers of particle board, so if a particle board industry is to be developed to use otherwise unwanted wood, then domestic markets for this product will have to be developed in the tropical countries.

Wood fuel is, of course, a well established forest product in the tropics. Some 80 per cent of the wood harvested from tropical forests is used as fuel. Unfortunately, the big centres of wood fuel consumption are the urban centres, not the rural areas where mechanically processed wood factories are often located. Nonetheless, for many countries, wood for fuel may be the most promising form of using otherwise unwanted species. Fuel may have to be produced in forms that are higher in calorific value and more easily transportable than solid wood. Charcoal and methanol are two such forms.

The technology is available, entry costs are relatively low and a substantial domestic market exists in virtually every developing country. In any case, some form of raw material indiscriminate industry is an essential part of the manufacturing mix to secure high levels of utilization of natural tropical forests.

What are the market opportunities in the mechanically processed wood sector which might encourage a rational long-term forest development strategy and the long term investments that such a strategy requires?

The greatest single set of opportunities lies in the development of domestic markets for mechanically processed wood and this means development of the local housing and commercial building market. As previously noted, mechanically processed wood is predominantly used in the construction of buildings. The tropical countries have very large populations that are poorly housed. These large populations constitute the greatest opportunity to expand markets for sawnwood, plywood and particle board anywhere in the world. Experimentation with unused or underused local species for housing applications, can be undertaken in local domestic markets in a way which would not be feasible in export markets.

A major thrust of forest product development in the developing countries of the tropics ought to be to increase consumption of mechanically processed wood, and then to increase production of these commodities based upon local resources. Out of such a development opportunities will emerge to serve the broader world market through exports. However, an effort to build a sound long-term mechanically processed wood sector on foreign markets alone is not likely to be very successful. Too much of the forest resource will only be useful for products whose value will not carry the costs of long distance transportation.

3.6. Structure of the industry

The structure of the forest utilization system includes four principal components, namely: the forest, the harvesting operation, the manufacturing operation and the marketing process. This paper is concerned with just a portion of the system - the manufacturing and marketing of mechanically processed wood. An integrated forest utilization system, however, includes all of the other components.

Unlike many natural resource utilization systems, where a single enterprise controls all phases of the operation from ownership of the raw material resource to the sale of the primary product, the forest utilization system often involves a whole series of ownerships and sometimes great physical distances between operations.

The entire system may be under single corporate ownership and management. The firm owns the land and grows the trees, harvests the forest, manufactures the products and markets them. At the other extreme, the system may involve multiple ownership and management, with each phase of the system falling under different ownership. The government may own the land, grow the trees and then sell them. A logging contractor might buy the trees, log them and convert them into roundwood components for sale to one or more manufacturing firms, who then produce the commodities and sell them to the consumer.

The manufacturing system may be very simple, consisting of a single sawmill only. On the other hand, it might be very complex, comprising several highly integrated mills that, in combination, utilize most of the biomass of the forest. In any case, the four components: the forest, harvesting, manufacturing and marketing are common to all configurations.

Moving through the system from forest stand to product sales, the process becomes more sophisticated and makes greater demands upon such limited resources as capital, energy and highly skilled manpower. The process of growing trees and harvesting them can be labour intensive, generally calling for unskilled or semi-skilled manpower, and low in requirements for energy and capital, though this is not always the case. Manufacturing involves heavier demands upon capital and energy and requires manpower with more technical and management skills. Marketing generally requires managerial and administrative competence of a high order.

Sometimes all of the components of the system may be located in a relatively compact geographical area. In this case, the cost of transporting material through the process from forest to commodity may be minimal. This is a very important consideration since wood is a very bulky material and its yield from tree to saleable commodity is sometimes low. When the factory is a great distance from the forest, roundwood transportation can involve expenses for transporting water and wood and bark residues that are not ultimately a part of the final saleable product.

When the entire system is under a single ownership and management, it may be easier to locate the factory so as to maximize the return of investment to total integrated system. If separate ownership and management are involved in the system, then one is dealing with sub-optimizations. Where the owner of the land and timber is the government, it can use its regulatory powers to influence the system and achieve its objectives. Tariffs, quotas and incentives are some of the regulatory tools commonly used.

Some governments have devised procedures for integrating the public tree-growing role with the private sector manufacture and marketing role. Long-term contracts are used to ensure that the private contractor is involved in the long-term tree growing function, as well as the harvesting and manufacturing systems, through contractual assurance of involvement over more than one timber rotation. The concession contracts between contractors and the Province of British Columbia (Canada), for forest utilization operations on Crown lands, are cases in point. It is particularly important to make these sort of long term arrangements where the landowner intends to convert from a natural forest to a managed plantation forest after the first rotation. The kind of manufacturing facilities required to produce mechanically processed commodities from natural forests may be quite different from those required to process second growth plantation grown trees.

When structural products are produced for sale in world markets, they must be of species that are known in those markets and for which there is a market demand. This is no problem when the forest is a pure stand of Douglas fir or Norway spruce. But when the forest is a natural stand of all-aged, multi-species hardwoods of the sort that are typical of the humid tropics, the problem is more complex. Such a forest may have 100 to 150 different species of trees that grow to a size that will permit manufacture into lumber or plywood. Of that number perhaps two or three are known in world markets and possibly ten to fifteen are known and acceptable in domestic markets. The task of the manufacturer who wishes to reduce his costs, is to increase the number of species that can be processed and sold. The task of introducing a new species into the world market for sawnwood or plywood is a formidable one. It can rarely be done effectively by a single country. New species can be much more easily introduced and tested first in local markets and then, when properties are known and a dependable supply is assured, they can be tested first in small quantities, in world trade.

One of the characteristics that typifies mechanically processed wood commodities is that they have a high volume to value ratio compared with many competitive materials. This property of structual wood products might reasonably be expected to favour manufacturing near the source of raw material. This is especially true since the conversion of logs to sawnwood or plywood usually results in a low recovery of wood in finished products. One reason that multinational firms prefer to ship logs to the consumer country for manufacturing is that their integrated utilization systems permit allocation of logs to the most appropriate product line and the use of residues for fuel or as raw materials for other products, an option not often available when manufacturing is done in the tropics.

One of the incentives for requiring that logs be processed in the country of log origin is value added from processing. In a forest utilization system at each phase of production, work is done on the products and money invested in it to advance it through the system.

Value added by manufacture is the portion of the income from sale of the product that is represented by wages and salaries, marketing expenses, interest on capital, depreciation, taxes, and profits. The figure below illustrates the relationship of these processing costs to other inputs and the output of the production system.

Schematic illustration of value added in the manufacture of plywood

Raw and other materials:		Value added:		Output:
Logs		Salaries and wages		Finished
Adhesives	+	Marketing	=	products
Tape		Interest on capital		
Sandpaper		Depreciation		
Other supplies		Taxes		
Fuel and power		Profit		

Developing countries often restrict the export of logs for processing elsewhere in order to secure local expenditure on components of value added for the benefit of the people and their government. Although this is often the result of such restrictions, it is not always the case. Analysis of value added by manufacture should be carefully made before assuming that in-country processing is in the best interest of the people of the log-producing nation. It is not necessarily true that expenditures for value added in manufacture will accrue to the people and government of the country where manufacture occurs. The ways in which these expenditures can leak out of the country are as follows:

- If the labour and management skills required to operate the manufacturing and marketing enterprise are not available in the country of log origin, and must be provided by expatriate employees, the ways and salaries component of value added in manufacture may not contribute significantly to the income of the indigenous population. Indeed, some of these funds may be exported out of the local economy.

- Typically, log export prices include a variety of government taxes and assessments that are not charged against domestically processed logs.

- If foreign capital is used to finance the manufacturing operation, the interest on these investments may be exported.

- If manufacturing equipment must be imported, depreciation on that equipment is effectively exported.

- To the extent that foreign equity is required to build and operate the manufacturing facility, some of the corporate profits may move out of the country.

All of these leakages may have the effect of significantly reducing the benefits to the country from value added in manufacture. If, as a consequence of restrictions on log exports, sales of manufactured products cannot be maintained at a level that will utilize the same log volume as could be sold for export, the advantages of capturing value added in manufacture may be more apparent than real.

3.7 Technology

Technology in the mechanical processing of wood ranges from primitive to complex and the whole spectrum is represented in some of the developing countries. As long as wood, energy and manpower are plentiful and inexpensive, simple technology is adequate for the production of lumber and plywood. The cost of building a plant to manufacture these products is relatively small compared to the investments usually required to enter the resource conversion field. According to Takeuchi (1982):

> "A typical modern sawmill with the rated annual capacity of 15 000 m^3 of sawnwood output would today require a total investment of US$ 2.0 - 5.0 miliion (constant 1980 dollars). In other words, initial investment requirements range from US$ 130 to 330 per cubic metre (sawnwood of annual production capacity)."

The same author reports the cost of building a modern plywood plant to be in the range of US$ 110 to 540 per cubic metre of rated capacity of plywood output. Particle board plants are reported to be substantially more expensive. These data are estimates for plants to be built in Southeast Asia.

In most parts of the world, even in the developing countries, wood is becoming expensive, energy is scarce and costly and, in some areas, manpower is increasingly expensive as well. The modern development in technology in the mechanically processed wood industries are, for the most part, directed to conserving the limited resources of wood, energy and manpower.

3.7.1 Technology to conserve wood

Improvements in technology designed to conserve wood in the course of producing mechanically processed commodities, often involve both the methods of processing of those commodities and the integration of that processing with fuel and fibre processing. In many industrial countries, integrated forest products conversion processes are designed to utilize virtually the whole tree. The question here is not so much what will be used or wasted but how to allocate the biomass among the available conversion processes.

The use of modern computer technology and electronic sensing technology has been introduced in the manufacture of sawnwood to improve dimensional precision and to minimize the allowances for shrinkage and mis-manufacture. Improved saws with thinner kerfs are also designed to increase the yield, and better control over temperature and relative humidity has reduced drying degrade losses.

Probably at least as important as the improvements in equipment technology are the improvements in managerial technology. These involve the adaptation of operational research methods to the managerial decision-making task. A variety of computer-assisted simulation, linear programming, dynamic programming and goal programming methods assist the managerial team to make prompt decisions that control and improve yield. In those few areas of the developing world where raw material for the manufacture of mechanically processed wood is still of low cost, it may be feasible to establish small and inexpensive mills that do not use modern yield improving technologies. Sawmills of this type in the industrial countries are going out of business during the current economic recession and will be replaced by high technology mills when the business climate improves. As the developing countries tap increasingly remote areas for raw materials and as they turn increasingly to plantation grown wood which carries the cost of establishment and growth, they will have to utilize the raw material conservation potential of these technologies in order to be competitive.

Another area of technological development important to the conservation of wood is technology designed to improve quality control. Products have to meet the specifications and standards of the market place to ensure that they will not be rejected or downgraded and that their service life will be reasonably long.

In the manufacture of sawnwood, modern quality control technology involves instrumented stress grading and non-destructive testing, as well as improved methods for the electronic measurements of moisture content.

In plywood manufacture, the development of new and improved adhesives has led to the development of better methods for testing the durability of glue bonds.

It is sometimes thought in developing countries, where labour is plentiful and inexpensive, that labour can substitute for expensive modern technology; and often it can. Technology designed to save labour, for example on handling of materials, is not essential in a country with abundant manpower. However, technology designed to improve yield or product quality is necessary in a developing country if domestic markets are to be established and expanded and a good reputation for quality of product earned in world markets.

3.7.2 Technology to conserve energy

One characteristic of the mechanical wood-processing industries is that they tend to produce, in combustible residues, more fuel than is required to provide the energy needed to operate the factory (National Academy of Sciences, 1976). This is generally true even where the clean wood residues are required as raw material for pulp manufacture. As a consequence these industries can be essentially energy independent and are thus attractive as manufacturing enterprises for countries where industries require energy in the form of heat to dry wood or heat logs, and in the form of electricity to operate electric motors, they can usefully operate co-generation plants that produce relatively high pressure steam and operate turbo-generators to provide electricity, while utilizing the exhaust steam for heating. Since the sawmill and plywood industries can produce a surplus of heat and electricity, they can support such energy deficient conversion processes as fibreboard, pulp and paper when these are a part of the same complex. In some small rural communities where mechanical processing plants are located, the surplus electricity and heat can be sold to meet community needs and provide additional income to the factory.

Unfortunately, many sawmills and plywood plants in developing countries are not taking advantage of these opportunities. In some developing countries new plants are being designed and built to use diesel oil for fuel, where that oil has to be imported and is a drain on foreign exchange. To take advantage of the opportunity to become energy self-sufficient, a mill must be larger than the minimum size mills often installed. With today's best available technology a sawmill, for example, must generally be large enough to produce in the range of 140 to 190 cubic metres of sawnwood per day to justify a co-generation plant. A comparable size plywood factory would also be needed. If an integrated utilization complex were to include more than one plant for mechanically processing wood, then theoretically each plant could be smaller since the co-generation plant would serve all mills.

3.7.3 Tecnology to conserve manpower

In the industrial countries of the world, the cost of labour is a very significant component of the cost of mechanically processed wood commodities. These products are historically labour-intensive. It has become important, therefore, to develop the technology to reduce the manpower requirements per cubic metre of output. This technology has often taken the form of developing materials handling equipment for moving work in process through the various stages of the manufacturing process, using mechanical, hydraulic or pneumatic labour substitute equipment, often controlled electrically, electronically or with micro-processors.

In many of the developing countries labour is still plentiful and relatively inexpensive. Furthermore, in many of these countries, increasing the employment opportunities is an important social objective. Under these circumstances the installation of expensive labour-saving devices may be counter-productive.

A small sawmill requires six to eight men to operate the machinery, the headsaw, edger and trimmer. In many developing countries, such a mill might employ twenty or thirty labourers. Only six or eight operate the sawmill equipment, all the rest are used to handle materials from logs in the yard or log pond, the intermediate slabs and partially processed boards, to finished lumber stacked for drying or sale. In an industrialized country these labourers might be replaced by cranes, front-end loaders, roll conveyors, belt conveyors and lift or straddle trucks, all requiring only four or five operators. In the developing country this trade off may be most appropriate.

Mahlberg (1978) studied manpower requirements in the primary mechanical wood industries in several countries in Asia. His findings indicated that the fraction of unskilled, skilled, technical and supervisory personn these industries did not vary greatly from country to country. The requirements in each category, not surprinsingly, were a function of the structure of the manufacturing component of the industry. The quality of output was related directly to the competence level of personnel in the skilled labour, technician and supervisory categories.

3.8 Institutional infra-structure

The specification and assurance of quality are important to the marketing of any product. One of the problems faced by the mechanically processed wood industries, particularly the sawnwood industry, is that they are made up of many small and independent companies. Some companies may meet specifications and standards for quality regularly while others may not. Often the whole industry gains a poor reputation from the performance of a few irresponsible members. In fragmented industries, the development of national standards and industry-wide quality assurance programmes have proved to be useful in encouraging some uniformity in performance.

3.8.1 Specifications and standards

In the mechanically processed wood industries, grading rules usually involve separation into categories based upon natural characteristics such as knots, figure, grain, and colour, as well as upon characteristics that derive from manufacturing such as, splits, checks, moisture content and, in the case of plywood, blisters, short faces, core gaps, etc. The specifications for commodities that have been promulgated by the industrial countries have often been adopted by the developing countries, whether they are appropriate or not. This often arises from the fact that the industrial countries, as the customers for exports from developing countries, insist upon purchasing to their own customary grading rules. This can introduce some problems for the developing country. First, the natural characteristics of the species in the developing country may not be the same as the natural characteristics upon which the grading rules or specifications were based. This can be particularly difficult if the developing country must conform to several specifications and standards to meet the needs of customers in different industrial countries. Size standards and units of measure may also differ from one consumer region to another. The need to manufacture to a multiplicity of standards, increases the problems of stock inventory and of training graders and inspectors. In some cases, producers in the developing countries can arrange to use modifications of existing international standards to adapt them to the species being used. For example, a special species rule as an addendum to the general U.S.A. grading rules promulgated by the National Hardwood Lumber Association, is a device that has been used successfully in the past. It avoids the need for general acceptance of a small special purpose rule and, at the same time, it takes care of the unique species problem.

It is difficult for a single producer to deal effectively with specifications and grading rules. In some developing countries, trade associations, made up of all the sawnwood producers or all the plywood producers in the country, have proved to be useful organizations for dealing with problems of specifications and standards. A good example of this procedure is the successful development of log and lumber grades by the government and industries of Malaysia. These grading rules have been widely accepted in the consumer countries and provide a sound basis for marketing Malaysian wood products.

It is often the case in developing countries that products produced for domestic consumption are sold mill run and ungraded. This has several disadvantages for producers. The factory is not tooled up and its employees are not trained to do the grading tasks required when there are opportunities to export. It has another disadvantage in that it does not provide for the sale of upper grades in export and of lower grades in the domestic market, a practice that is usually esential if a factory, or a country for that matter, is to be competitive in world trade.

3.8.2 Quality control

Industry-wide quality control has proved to be a very useful device for promoting the sale of mechanically processed wood commodities in industrial countries. Often conducted by a trade association, it is an industry-wide quality assurance procedure that gains the confidence of consumers, provides a solid basis for the adjudicating of seller/buyer disputes and is very effective as the basis for trade promotion, both domestic and international. A long established programme of this sort is the one conducted by the American Plywood Association (A.P.A.) of the U.S.A. Developed orginally around west coast softwood plywood, when the Association was known as the Douglas Fir Plywood Association, the A.P.A. programme now embraces many species, including the southern pines and some of the dipterocarp species of Southeast Asia. The A.P.A. is the custodian of the plywood specification upon which the programme is based, though the specification is actually promulgated by the United States Department of Commerce. The specification includes grading rules for a whole series of plywood grades. It also includes performance requirements for adhesive bonds and the procedures for testing bond adhesion performance.

The leverage which the Association has in enforcing compliance with specifications is its ownership of the plywood grade marks and its right to grant or withold use of those grade marks, depending upon the quality performance of the member mills.

The Association performs its quality assurance programme by conducting spot checks of the grading performed at any factory and by regularly testing panel samples to determine quality of glue line. A factory that does not conform to association rules for compliance with the industry standards is denied the use of A.P.A. grade marks. This can adversely affect the companies ability to market its plywood.

For some developing countries, where product quality has been a major deterrent to effective marketing, a country-wide or industry-wide quality assurance programme might be an effective trade promotion and marketing tool.

3.9 Market and trade relations

The nature of world trade in the mechanically processed wood commodities was reviewed earlier in this paper and that will not be repeated here. The essence of market expansion for the developing countries is to enlarge their own domestic markets first and, building upon this, to develop opportunities for expanded export trade. This is particularly true as the developing countries press vigorously for the elimination of log exports in favour of domestic processing and simultaneously for a reduction in foreign equity in the processing industries. The multinational firms based in industrialized countries are often the purchasers of the exported logs and, as frequently as not, are the partners in the joint ventures that built and operated the factories whose products are being exported. A major role of the multinational partner has been to provide a world-wide maketing system, market intelligence and a knowledge of international grades and standards and quality expectations. Lacking the input from the multinationals, firms in the developing countries need to build a marketing strategy based upon a strong domestic market.

3.9.1 The secondary species problem

One of the problems of marketing the products from humid tropical forests, stems from the species diversity in these forests. In addressing this question Cliff (1973) noted:

> "Characteristically, tropical rain forests are a mixture of large numbers of species. As many as several hundred per hectare have been reported. Most of these species are not used in commerce. Their wood properties vary widely and have not been well defined in terms that can be used in developing markets for them.
> The problem of heterogeneity is greatest in Latin America, is less severe in Africa, and least in Southeast Asia, although it poses serious obstacles in all three".

Referring again to Figure 1, which describes a utilization system that is appropriate to a forest in Costa Rica, the secondary species are those included in the category "non-commercial". In the language of agriculture these are weeds until someone finds a use for them. Selective harvesting practised extensively in much of the tropics compounds the secondary species problem. The commercial trees are cut and the non-commercial left. As a result, the forests are being increasingly dominated by those species for which there is either no market or a very limited one.

The Secretariats of FAO and UNCTAD (UNCTAD, 1977) reported on this problem as follows:

> "A number of reasons can be adduced to account for the persistence of the secondary species problem which has received so much attention in the past. But it is as well to note that what is happening in the tropical timber forests corresponds to the standard historical pattern of forest utilization (and resource utilization generally for that matter): the best in quality, the easiest to log and sell, go first. They are, at any stage, the preferred or economic species. This can lead to an irrational pattern of utilization, and indeed countries of experience provide innumerable examples of the widespread, long-term disastrous effects of working other types of forest in that way."

To develop a marketing base for a multispecies, all-aged natural forest is a formidable task. It requires that the properties of the secondary species are determined and catalogued. On the basis of such a systematic cataloguing, potential uses can be identified and then tested in the local market. Even if it is determined that a species has a potential market there may be problems of supply. Many of the secondary species occur only once every two or three hectares. It would take a long time to accumulate a vehicle load of lumber or plywood from such a species. It is disastrous in any market development scheme to develop a customer interest in a new species and then be unable to deliver when he is ready to buy.

One way to deal with the problem is to reverse the botanists taxonomic splitting exercies and undertake lumping instead. Species that are botanically unrelated may be very similar in properties. They can be combined under a single trade name if they are sufficiently similar in properties to allow them to be interchangeable in use.

One of the reasons the secondary species problem has been so persistent is the lack of strong research and development programmes in wood technology in the developing countries. Logs and timber are such bulky commodities that they cannot readily be shipped to large laboratories in the industrial countries. The research and development need to be done in laboratories in the developing countries near the forests.

A second way of dealing with the secondary species problem is simply to eliminate the secondary species. The natural forest is removed and replaced by an even-aged, single-species plantation, where the species selected is one which has a domestic or export market already established. Undoubtedly some developments from natural to intensively managed forest will take place. Much of it may be to supply long fibre for the pulp and paper industry, but some will be for the production of mechanically processed wood commodities as well. However, there will continue to be large areas of natural forest or secondary forest and it is the marketing of products from these mixed hardwood forests that is the challenge.

3.9.2 The domestic market problem

The basic problem in the development of a domestic market for mechanically processed wood in the developing countries is that most tropical countries have not traditionally been large consumers of these products. The principal use of wood in the tropics has been as a domestic fuel. Where wood is used in building construction it is often in the homes of the very poor where it is generally used in pole or rough hewn form. In the homes of the very wealthy it is used for decorative purposes and furniture, or temporarily as framing, forms or scaffolding in the construction of concrete and steel buildings.

Can a market for wood building materials be created locally in the presence of such a tradition? There is reason to believe that it can. The tropical countries have been increasing their consumption of structural wood in recent years and there is reason to expect this increase in consumption to continue. Mechanically processed wood in the form of sawnwood, plywood, and particle board makes a much smaller demand upon energy resources than does steel, aluminium or concrete. As already noted these mechanically processed wood commodities can be produced in manufacturing facilities that are energy independent, the basic raw material itself being a product of solar energy. In those developing countries where fossil fuels and hydro-electric power are expensive and in short supply, these energy advantages should improve the climate for creating a domestic market for structural wood. It may be necessary to be innovative in the way tropical woods are used and in the application of preservatives to counter the conditions conducive to decay that prevail in the tropics. There is, in fact, much information on tropical woods for structural uses that has been developed in laboratories such as those of the Timber Research and Development Association of the United Kingdom and the Commonwealth Scientific and Industrial Research Organization of Australia. In support of the development of local markets for structural wood, these research efforts need to be extended in the developing countries themselves.

3.9.3 Transport problems

As the developing countries move in the direction of increased domestic manufacture and decreased sales of logs, they face the need for an adequate transport infrastructure.

A log export operation can often be developed with a minimum road, rail or water transport network, to move the logs from the forest to a safe harbour where ocaen-going vessels can be loaded. The ship terminal facilities required to load logs are minimal. Often they can be loaded directly from rafts or barges using the ship's cranes while the ship is at anchor.

If sawnwood or plywood is to be shipped for export, the problems of transport are considerably greater. The products of the mills must be moved to a port that has the facilities for unloading, protected storage, and dockside loading. Whereas logs are often shipped as whole ship loads to a manufacturing plant, finished products will usually be shipped as partial cargoes with other commodities to consumers in many locations. If the mill is not built in a port city, or is not readily accessible to a port city, it may be necessary to build the port facilities to accomodate ocean transport for the mill's products.

3.9.4 Sales organizations

The developing country that elects to assume the manufacturing role in the production of structural wood products must also decide whether it wishes to assume the marketing role as well. In the field of world trade (export and import), this is an area where the multinational firms play an important role. They operate world-wide marketing networks that include sales offices and sales personnel in the principal consumer centres. They serve as centres of market intelligence leading to product distribution decisions and product pricing. Transport and transport financing arrangements, the financing of sales, monitoring of quality assurance and adjudication of customer complaints, are all included in the merchandising role performed by multinational firms acting as trading companies.

Multinational firms in the forest products industry are often small, relative to those in some other fields, but they are nonetheless large compared to most single factory manufacturing firms. The smaller company must handle for itself all of the merchandising functions performed by the multinational firm. It can be done, and many small individual firms do it through the use of the facilities of independent agents and brokers. It is also possible to contract with multinational firms to provide the merchandising services. There is, of course, a value-added component of the marketing function, and the organization performing the function will expect to reap the financial rewards.

One option for the individual mill that wishes to sell some of its products in export markets is to join with other firms with similar objectives and, perhaps with banks or shipping companies, to organize a trading company that can provide the essential export marketing services to all of the member companies.

3.10. Manpower

The mechanically processed wood industries are very labour-intensive industries. The modern factories in industrial countries tend to be less labour-intensive than older mills, while the mills in developing countries, where labour is inexpensive, tend to be the most labour-intensive. Within the structural wood industries themselves there is variation in labour requirements. Generally, sawnwood manufacture has the greatest labour requirement per cubic metre of output, followed by plywood which has less, and finally by particle board which has the least of all.

According to Simula (1976), the labour requirement for the manufacture of veneer in West and Central Africa ranged from 23 to 60 man-hours per cubic metre and from 36 to 140 man-hours in the production of plywood. This author states that, in Europe, manpower requirements for plywood manufacture range from 20 to 30 man-hours per cubic metre. Mahlberg (1978) studied the education and training needs of the primary mechanical wood industries in several countries of Asia. He found, as an example, that in Bangladesh the labour requirements in sawmills exceeded 50 man-hours per cubic metre, while in Burma they were in the range of 50 to 80 man-hours per cubic metre for sawmills and an average of 70 man-hours per cubic metre for plywood plants. Singapore, on the other hand, has mills that are very efficient in manpower utilization. According to the same author, sawmills in Singapore required 5 man-hours per cubic metre and plywood mills 22 man-hours per cubic metre.

In general, sawmills and plywood mills with high labour requirements per unit of output, tend to be factories that use manual labour for materials handling between operations. This is unskilled labour and is usually paid at or near the lowest industrial wage rate in the country. The better mills have well-trained and experienced machine operators and supervisors. Unfortunately, few of the developing countries are in a position to train the skilled machine operators and supervisors necessary to operate efficient and profitable factories. As mills inevitably become more complex, the need for well-trained technicians will increase. In many developing countries, modern sawmills and plywood factories use expatriates in supervisory positions and sometimes as operators of key equipment. This is in spite of the fact that government policy in many of these countries is to eliminate expatriates and to substitute them with national personnel. A scheme sometimes adopted for development of skilled workers, is to use qualified expatriates at the beginning of a new mill's operation with the understanding that each expatriate will train a local successor to replace him. As often as not this system has not proved satisfactory. Mahlberg (1978) has noted with respect to Indonesia:

> "There is a shortage of skilled personnel at all levels. The enterprises are allowed to employ expatriates for a limited time, during which they are expected to train their Indonesian counterparts. At present, 170 expatriates are employed in the Indonesian wood industry. This on-the-job training without supervision has evidently been less successful than expected, and the trend is to extend the stay of the expatriates for longer times than the regulations permit. This situation is likely to continue as long as no systematic training in wood technology for the needs of the primary wood industry is initiated."

Probably the greatest deficiency in manpower in the mechanically processed wood industries is in the area of forest products management. In addressing the problem of education and training for the mechanical forest industries, Leslie (1981) pointed out:

> "Traditionally, education and training needs have been analysed more or less from the point of view of the educational ladder - vocational, sub-professional and tertiary. This approach can produce results, as shown by the rather successful programme on the forestry side of the sector. However, as we are going back to first principles, it could be worth looking at the training and educational needs from a functional point of view

- managerial, supervisory and operative - and to see to what extent these needs are met by existing institutions. One of the first things that such a review would have to take into account is the desperate weakness of management in the forest industries of developing countries ..... The functional level which integrates all the elements in the system and, at the same time, controls the system, is that of management. This seems therefore the logical place at which to start a training programme for forest industries."

In most developing countries that have a significant forest resource, training for employment in the mechanical processing industries at the vocational or technician level ought to be done in the country. For many countries the number of wood technologists required for managerial level posts may be too small to justify a curriculum in the university. For these countries, sending students abroad may represent a reasonable solution.

3.11. Recommendations

3.11.1 Constraints to development of primary industries

Lack of a domestic market

For many developing countries, the principal effort in the domain of the mechanical processed wood industry is to develop an export market. To do this in the absence of a strong domestic market is difficult and hazardous. The domestic market is the place where lower grade can be sold, thus increasing the yield from a tree. It is the place where the use of new species can be tested.

Lack of complementary industries

The structural wood products that come from the mechanical wood processing industries are among the most valuable products from the forest. A relatively small fraction of the trees in the tropical forest are selected for these products and a relatively small fraction of the selected trees end up in the finished product. If non-utilized trees and residues can be used for fuel or fibre products - uses that are relatively indiscriminate with respect to size and quality - then the production of such products as sawnwood, plywood and particle board becomes more feasible.

Lack of long-term raw material base

In most developing countries the mechanically processed wood industries do not own the forest land or produce the trees. They are dependent upon the custodians of the forests for raw materials. In many countries the conversion of forest to other uses, and the degrading of natural forest though selective fallings, result in uncertainty about the future supply of raw material for these industries. For many countries the development of intensively managed forests is the only reasonable basis for assuring the future of a mechanically processed wood industry.

Lack of forest products managerial talent

For developing countries that have been involved in the mechanically processed wood industry primarily in the role of supplier of logs, the need for skilled managers of factories has not been critical. Even when the wood products are manufactured within the country, if the factories are operated by multinational corporations through joint ventures with multinational corporations, the managerial talent is normally provided by expatriates associated with the multinationals. With a greater assumption by the domestic firm of manufacturing responsibility, the need to develop native manufacturing managerial talent is crucial to success.

3.11.2 Opportunities for regional co-operative efforts

Quality control

The development of industry-wide grade standards, grade marking and quality assurance programmes may be inadequate if they are undertaken within each country. In fact, they might simply be confusing. Regional programmes of this sort, developed through wider co-operative agreements and using common inspection and testing facilities, might be effective in establishing product quality reputation.

Trade promotion and market intelligence

Just as a regional quality control programme might be more effective and efficient than multiple country programmes, a trade association that has regional responsibility for promoting the structural wood products of the region and for providing information on markets and prices to member companies, might advance the effectiveness of the whole region.

Research on secondary species

The "secondary species" problem has been an inhibiting factor in the development of structural wood products from natural forests in the tropics. Research, to determine the properties, design potential and manufacturing characteristics of these woods, will improve opportunities to market them and specifically to group them for simplified marketing. This type of research needs to be done in the developing countries of the tropics, but it need not be duplicated in every country. Regional laboratories and regional research efforts could contribute solutions to the "secondary species" problem.

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Table 3.1 Apparent consumption of mechanically processed wood by regions 1970 and 1980
Volume in million m^3

Region	1970	1980
World	481,941	524,882
Africa	6,389	10,415
North America	131,020	139,689
Central America and Caribbean	4,038	4,437
South America	13,282	22,593
Asia	87,570	102,915
Europe	114,645	135,660
Oceania	7,086	6,895
U.S.S.R.	117,915	102,281

Source: Derived from FAO Yearbook of Forest Products 1980

Table 3.2 Apparent consumption of conifer sawnwood by regions 1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	311,702	317,917
Africa	2,970	3,370
North America	84,181	87,952
Central America and Caribbean	2,505	1,907
South America	4,959	8,552
Asia	49,544	56,855
Europe	70,613	75,804
Oceania	3,022	3,114
U.S.S.R.	93,908	80,364

Source: Derived from FAO Yearbook of Forest Products 1980. Data exclude railway sleepers

Table 3.3 Largest consumers of conifer sawnwood in 1970
Volume in 1,000 m^3

	Country	Volume
1.	U.S.S.R.	93,908
2.	U.S.A.	75,701
3.	Japan	35,358
4.	Germany, Federal Republic	11,270
5.	China	8,919
6.	Canada	8,470
7.	France	7,204
8.	Poland	5,299
9.	Sweden	5,221
10.	Brazil	3,608
	Total	254,958

Source: Derived from FAO Yearbook of Forest Products 1980. Data exclude railway sleepers.

Table 3.4 Largest consumers of conifer sawnwood in 1980
Volume in 1,000 m^3

	Country	Volume
1.	U.S.S.R.	80,364
2.	U.S.A.	75,822
3.	Japan	35,595
4.	China	13,265
5.	Germany, Federal Republic	12,502
6.	Canada	12,130
7.	France	8,091
8.	Brazil	7,150
.	Sweden	5,438
1	Finland	3,257
	Total	253,614

Source: Derived from FAO Yearbook of Forest Products 1980. Data exclude railway sleepers.

Table 3.5 Apparent consumption of non-conifer sawnwood by regions 1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	92,217	102,648
Africa	2,517	5,430
North America	18,506	18,700
Central America and Caribbean	751	1,110
South America	6,883	11,148
Asia	26,798	29,202
Europe	19,043	22,006
Oceania	2,919	2,419
U.S.S.R.	14,800	12,632

Source: Derived from FAO Yearbook of Forest Products 1980. Data exclude railway sleepers.

Table 3.6 Largest consumers of non-conifer sawnwood in 1970
Volume in 1,000 m^3

Country	Volume
U.S.A.	17,359
U.S.S.R.	14,800
Japan	10,033
China	5,532
France	3,424
Brazil	3,353
Australia	2,706
Italy	2,393
Germany, Federal Republic	2,164
India	1,951
Total	63,715

Source: Derived from FAO Yearbook of Forest Products 1980. Data exclude railway sleepers.

Table 3.7 Largest consumers of non-conifer sawnwood in 1980
Volume in 1,000 m^3

Country	Volume
U.S.A.	16,829
U.S.S.R.	12,632
China	7,745
Japan	6,894
Brazil	6,621
France	4,517
Italy	2,793
Nigeria	2,691
Germany, Federal Republic	2,611
India	2,427
Total	65,760

Source: Derived from FAO Yearbook of Forest Products 1980. Data exclude railway sleepers.

Table 3.8 Apparent consumption of market veneer by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	3,348	5,087
Africa	121	189
North America	478	441
Central America and Caribbean	3	25
South America	88	202
Asia	482	1,442
Europe	1,620	2,198
Oceania	63	66
U.S.S.R.	495	527

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.9 Apparent consumption of plywood by regions 1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	33,402	39,156
Africa	276	573
North America	17,347	18,624
Central America and Caribbean	206	504
South America	541	899
Asia	8,178	11,457
Europe	4,830	5,192
Oceania	204	184
U.S.S.R.	1,820	1,723

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.10 Largest consumers of plywood in 1970
Volume in 1,000 m^3

	Country	Volume
1.	U.S.A.	15,734
2.	Japan	6,855
3.	U.S.S.R.	1,820
4.	Canada	1,613
5.	Germany, Federal Republic	713
6.	France	664
7.	Philippines	392
8.	Italy	332
9.	Brazil	314
10.	China	209
	Total	28,666

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.11 Largest consumers of plywood in 1980
Volume in 1,000 m^3

	Country	Volume
1.	U.S.A.	16,753
2.	Japan	8,402
3.	Canada	1,871
4.	U.S.S.R.	1,723
5.	Germany, Federal Republic	866
6.	France	712
7.	Korea, Republic of	666
8.	Brazil	647
9.	Italy	435
10.	Mexico	341
	Total	32,416

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.12 Apparent consumption of particle board by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	19,142	40,465
Africa	180	447
North America	3,441	7,728
Central America and Caribbean	80	482
South America	302	919
Asia	609	1,887
Europe	12,365	23,911
Oceania	316	665
U.S.S.R.	1,849	4,428

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.13 Largest consumers of particle board in 1970
Volume in 1,000 m^3

	Country	Volume
1.	Germany, Federal Republic	3,867
2.	U.S.A.	3,118
3.	U.S.S.R.	1,849
4.	France	1,302
5.	Italy	872
6.	U.K.	679
7.	Germany, Democratic Republic	663
8.	Belgium - Luxembourg	585
9.	Spain	465
10.	Switzerland	384
	Total	13,784

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.14 Largest consumers of particle board in 1980
Volume in 1,000 m^3

	Country	Volume
1.	Germany, Federal Republic	6,573
2.	U.S.A.	6,411
3.	U.S.S.R.	4,228
4.	France	2,180
5.	Italy	2,163
6.	Canada	1,317
7.	Poland	1,241
8.	Spain	1,052
9.	Japan	1,024
10.	Yugoslavia	824
	Total	27,213

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.15 Apparent consumption of fibreboard by regions 1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	14,212	16,268
Africa	129	157
North America	6,887	6,329
Central America and Caribbean	95	106
South America	297	740
Asia	1,126	1,363
Europe	4,215	4,639
Oceania	241	227
U.S.S.R.	1,220	2,705

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.16 Largest consumers of fibreboard in 1970
Volume in 1.000 m^3

	Country	Volume
1.	U.S.A.	6,009
2.	U.S.S.R.	1,220
3.	Canada	878
4.	Japan	708
5.	Germany, Federal Republic	571
6.	United Kingdom	493
7.	Poland	460
8.	Sweden	427
9.	Netherlands	282
10.	Brazil	225
	Total	11,273

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.17 Largest consumers of fibreboard in 1980
Volume in 1,000 m^3

	Country	Volume
1.	U.S.A.	5,602
2.	U.S.S.R.	2,705
3.	Canada	727
4.	Poland	676
5.	Brazil	608
6.	Japan	564
7.	Germany, Federal Republic	518
8.	China	461
9.	United Kingdom	381
10.	Sweden	340
	Total	12,582

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.18 Production of conifer sawnwood by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	312,174	322,445
Africa	1,518	1,891
North America	90,379	98,800
Central America and Caribbean	2,112	1,638
South America	5,308	9,458
Asia	46,043	50,282
Europe	62,384	70,155
Oceania	2,580	3,021
U.S.S.R.	101,850	87,200

Source: FAO Yearbook of Forest Products 1980.

Table 3.19 Largest producers of conifer sawnwood in 1970
Volume in 1,000 m^3

	Country	Volume
1.	U.S.S.R.	101,850
2.	U.S.A.	64,971
3.	Japan	32,750
4.	Canada	25,408
5.	Sweden	12,006
6.	China	8,990
7.	Germany, Federal Republic	7,458
8.	Finland	7,135
9.	Poland	5,885
10.	France	5,708
	Total	272,161

Source: FAO Yearbook of Forest Products 1980.

Table 3.20 Largest producers of conifer sawnwood in 1980
Volume in 1,000 m^3

	Country	Volume
1.	U.S.S.R.	87,200
2.	U.S.A.	58,300
3.	Canada	40,500
4.	Japan	30,705
5.	China	13,292
6.	Sweden	11,077
7.	Finland	10,152
8.	Germany, Federal Republic	8,442
9.	Brazil	7,334
10.	Austria	6,301
	Total	273,303

Source: FAO Yearbook of Forest Products 1980.

Table 3.21 Production of non-conifer sawnwood by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	92,631	102,804
Africa	2,208	5,662
North America	18,172	18,468
Central America and Caribbean	746	1,015
South America	7,321	11,569
Asia	28,562	32,566
Europe	17,794	18,913
Oceania	2,679	2,211
U.S.S.R.	14,550	12,400

Source: FAO Yearbook of Forest Products 1980.

Table 3.22 Largest producers of non-conifer sawnwood in 1970
Volume in 1,000 m^3

	Country	Volume
1.	U.S.A.	16,846
2.	U.S.S.R.	14,550
3.	Japan	9,827
4.	China	5,565
5.	France	3,555
6.	Brazil	3,500
7.	Malaysia	3,100
8.	Romania	2,543
9.	Australia	2,484
10.	India	1,950
	Total	63,920

Source: FAO Yearbook of Forest Products 1980.

Table 3.23 Largest producers of non-conifer sawnwood in 1980
Volume in 1,000 m^3

	Country	Volume
1.	U.S.A.	17,039
2.	U.S.S.R.	12,400
3.	China	7,807
4.	Brazil	6,736
5.	Japan	6,412
6.	Malaysia	5,147
7.	France	4,237
8.	Indonesia	3,400
9.	Nigeria	2,691
10.	Romania	2,464
	Total	68,333

Source: FAO Yearbook of Forest Products 1980.

Table 3.24 Production of market veneer by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	3,235	4,856
Africa	251	353
North America	220	500
Central America and Caribbean	4	23
South America	129	245
Asia	645	1,314
Europe	1,464	1,886
Oceania	47	59
U.S.S.R.	476	476

Source: FAO Yearbook of Forest Products 1980.

Table 3.25 Largest producers of market veneer in 1970
Volume in 1,000 m^3

	Country	Volume
1.	U.S.S.R.	476
2.	Germany, Fed. Rep.	370
3.	Japan	250
4.	Philippines	242
5.	Canada	220
6.	Yugoslavia	200
7.	Italy	180
8.	Germany, Dem. Rep.	170
9.	Brazil	96
10.	Spain	84
	Total	2,288

Source: FAO Yearbook of Forest Products 1980.

Table 3.26 Largest producers of market veneer in 1980
Volume in 1,000 m^3

	Country	Volume
1.	Philippines	660
2.	Germany, Fed. Rep.	505
3.	Canada	500
4.	U.S.S.R.	476
5.	Italy	450
6.	Japan	300
7.	Yugoslavia	250
8.	Brazil	200
9.	Malaysia	187
10.	Germany, Dem. Rep.	170
	Total	3,698

Source: FAO Yearbook of Forest Products 1980.

Table 3.27 Production of plywood by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	33,174	40,275
Africa	306	433
North America	15,929	18,338
Central America and Caribbean	147	417
South America	579	1,080
Asia	10,063	14,258
Europe	3,929	3,615
Oceania	176	146
U.S.S.R.	2,045	1,988

Source: FAO Yearbook of Forest Products 1980.

Table 3.28 Largest producers of plywood in 1970
Volume in 1,000 m^3

	Country	Volume
1.	U.S.A.	14,078
2.	Japan	6,922
3.	U.S.S.R.	2,045
4.	Canada	1,851
5.	Korea Rep.	847
6.	China	794
7.	Finland	706
8.	Philippines	653
9.	France	643
10.	Germany, Fed. Rep.	569
	Total	29,108

Source: FAO Yearbook of Forest Products 1980.

Table 3.29 Largest producers of plywood in 1980
Volume in 1,000 m^3

	Country	Volume
1.	U.S.A.	16,000
2.	Japan	8,400
3.	Canada	2,338
4.	U.S.S.R.	1,988
5.	Korea Rep.	1,575
6.	China	1,563
7.	Brazil	762
8.	Finland	639
9.	Philippines	553
10.	France	546
	Total	34,364

Source: FAO Yearbook of Forest Products 1980.

Table 3.30 Production of particle board by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	19,170	40,330
Africa	169	372
North America	3,410	7,367
Central America and Caribbean	72	460
South America	311	948
Asia	597	1,726
Europe	12,300	24,019
Oceania	318	743
U.S.S.R.	1,994	4,695

Source: FAO Yearbook of Forest Products 1980.

Table 3.31 Largest producers of particle board in 1970
Volume in 1,000 m^3

	Country	Volume
1.	Germany, Fed. Rep.	3,778
2.	U.S.A.	3,127
3.	U.S.S.R.	1,994
4.	France	1,237
5.	Belgium - Luxembourg	1,200
6.	Italy	920
7.	Germany, Dem. Rep.	580
8.	Austria	479
9.	Spain	444
10.	Sweden	389
	Total	14,148

Source: FAO Yearbook of Forest Products 1980.

Table 3.32 Largest producers of particle board in 1980
Volume in 1,000 m^3

	Country	Volume
1.	Germany, Fed. Rep.	6,262
2.	U.S.A.	6,100
3.	U.S.S.R.	4,695
4.	France	2,166
5.	Italy	1,700
6.	Belgium - Luxembourg	1,665
7.	Spain	1,330
8.	Austria	1,309
9.	Canada	1,267
10.	Sweden	1,193
	Total	27,687

Source: FAO Yearbook of Forest Products 1980.

Table 3.33 Production of fibreboard by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970	1980
World	14,207	16,514
Africa	134	81
North America	6,755	6,342
Central America and Caribbean	87	102
South America	331	921
Asia	1,076	1,289
Europe	4,198	4,525
Oceania	268	246
U.S.S.R.	1,359	3,008

Source: FAO Yearbook of Forest Products 1980.

Table 3.34 Largest producers of fibreboard in 1970
Volume in 1,000 m^3

	Country	Volume
1.	U.S.A.	5,821
2.	U.S.S.R.	1,359
3.	Sweden	991
4.	Canada	934
5.	Japan	707
6.	Poland	476
7.	Finland	379
8.	Germany, Federal Republilc	374
9.	France	364
10.	Norway	281
	Total	11,686

Source: FAO Yearbook of Forest Products 1980.

Table 3.35 Largest producers of fibreboard in 1980
Volume in 1,000 m^3

	Country	Volume
1.	U.S.A.	5,619
2.	U.S.S.R.	3,008
3.	Brazil	755
4.	Canada	723
5.	Poland	670
6.	Sweden	610
7.	Japan	570
8.	China	461
9.	Romania	311
10.	Spain	310
	Total	13,037

Source: FAO Yearbook of Forest Products 1980.

Table 3.36 Trade in mechanically processed wood by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970		1980	
	Imports	Exports	Imports	Exports
World	66,130	66,850	90,150	95,980
Africa	2,310	1,330	2,600	1,340
North America	17,620	21,660	26,780	36,910
Central America and Caribbean	1,120	480	1,040	510
South America	900	1,810	1,280	3,040
Asia	5,270	5,520	12,430	11,670
Europe	37,430	26,800	44,410	33,630
Oceania	1,100	420	1,150	930
U.S.S.R.	370	8,830	460	7,940

Source: Derived from FAO Yearbook of Forest Products 1980.

Table 3.37 Trade in conifer sawnwood by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970		1980	
	Imports	Exports	Imports	Exports
World	48,876	49,348	61,656	66,184
Africa	1,559	107	1,629	150
North America	13,859	20,057	22,765	33,613
Central America and Caribbean	816	423	697	428
South America	751	1,100	538	1,444
Asia	3,668	167	7,198	625
Europe	27,468	19,239	27,988	22,339
Oceania	717	275	728	635
U.S.S.R.	38	7,980	114	6,950

Source: FAO Yearbook of Forest Products 1980. Data exclude railway sleepers.

Table 3.38 Largest imports and exports of conifer sawnwood 1980
Volume in 1,000 m^3

Rank	Imports		Exports	
	Country	Volume	Country	Volume
1.	U.S.A.	22,169	Canada	28,966
2.	United Kingdom	5,983	U.S.S.R.	6,950
3.	Japan	4,899	Finland	6,898
4.	Germany, Federal Rep.	4,505	Sweden	5,888
5.	Italy	4,356	U.S.A.	4,647
6.	France	2,631	Austria	4,247
7.	Netherlands	2,412	Chile	1,258
8.	Denmark	1,232	Czechoslovakia	1,044
9.	Germany, Dem. Rep.	1,207	Portugal	1,005
10.	Belgium-Luxembourg	1,032	Poland	689
	Total	50,426	Total	61,592

Source: FAO Yearbook of Forest Products 1980. Data exclude railway sleepers.

Table 3.39 Trade in non-conifer sawnwood by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970		1980	
	Imports	Exports	Imports	Exports
World	6,756	7,170	12,506	12,662
Africa	456	747	485	717
North America	1,008	674	1,422	1,190
Central America and Caribbean	35	30	128	33
South America	116	554	620	1,041
Asia	916	2,680	3,188	6,552
Europe	3,689	2,440	6,114	3,021
Oceania	286	46	317	109
U.S.S.R.	250	-	232	-

Source: FAO Yearbook of Forest Products 1980. Data exclude railway sleepers.

Table 3.40 Largest imports and exports of non-conifer sawnwood 1980
Volume in 1,000 m^3

Rank	Imports		Exports	
	Country	Volume	Country	Volume
1.	Italy	1,347	Malaysia	3,141
2.	Singapore	1,098	Indonesia	1,190
3.	Germany, Federal Rep.	987	Singapore	1,134
4.	France	755	U.S.A.	885
5.	Canada	747	Yugoslavia	860
6.	U.S.A.	675	Philippines	742
7.	Netherlands	651	Brazil	567
8.	United Kingdom	634	France	475
9.	Thailand	557	Romania	421
10.	Japan	529	Germany, Fed. Rep.	368
	Total	7,980	Total	9,783

Source: FAO Yearbook of Forest Products 1980. Data exclude railway sleepers.

Table 3.41 Trade in market veneer by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970		1980	
	Imports	Exports	Imports	Exports
World	964	851	1,667	1,436
Africa	37	167	39	203
North America	450	192	398	457
Central America and Caribbean	1	2	2	-
South America	6	47	101	144
Asia	42	205	360	232
Europe	378	222	690	378
Oceania	20	4	20	13
U.S.S.R.	31	12	59	8

Source: FAO Yearbook of Forest Products 1980.

Table 3.42 Largest imports and exports of market veneer 1980
Volume in 1,000 m^3

Rank	Imports		Exports	
	Country	Volume	Country	Volume
1.	U.S.A.	368	U.S.A.	295
2.	Germany, Federal Rep.	151	Canada	162
3.	Israel	150	Malaysia	127
4.	France	136	Germany Fed. Rep.	76
5.	Brazil	87	Congc	67
6.	Italy	82	Paraguay	63
7.	United Kingdom	77	Philippines	63
8.	Singapore	67	Portugal	57
9.	Netherlands	67	Brazil	51
10.	U.S.S.R.	59	Ivory Coast	46
	Total	1,244	Total	1,007

Source: FAO Yearbook of Forest Products 1980.

Table 3.43 Trade in plywood and blockboard by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970		1980	
	Imports	Exports	Imports	Exports
World	4,700	4,472	5,789	6,908
Africa	97	127	221	81
North America	1,902	484	1,082	796
Central America and Caribbean	75	16	126	39
South America	6	44	8	189
Asia	457	2,342	1,182	3,983
Europe	2,060	1,159	3,047	1,470
Oceania	47	19	74	36
U.S.S.R.	56	281	50	315

Source: FAO Yearbook of Forest Products 1980.

Table 3.44 Largest imports and exports of plywood and blockboard in 1980
Volume in 1,000 m^3

Rank	Imports		Exports	
	Country	Volume	Country	Volume
1.	U.S.A.	1,001	China	1,240
2.	United Kingdom	772	Korea Rep.	946
3.	Netherlands	488	Singapore	616
4.	Germany, Federal Rep.	486	Canada	548
5.	Saudi Arabia	371	Finland	531
6.	France	335	Malaysia	474
7.	Singapore	248	Philippines	361
8.	Hong Kong	237	U.S.S.R.	315
9.	Belgium-Luxembour	209	Indonesia	253
10.	Denmark	156	U.S.A.	248
	Total	4,303	Total	5,532

Source: FAO Yearbook of Forest Products 1980.

Table 3.45 Trade in particle board by regions
1970 and 1980
Volume in 1,000 m^3

Region	1970		1980	
	Imports	Exports	Imports	Exports
World	2,020	2,048	5,615	5,480
Africa	21	10	77	2
North America	52	51	588	227
Central America and Caribbean	9	1	23	1
South America	2	11	-	29
Asia	27	15	210	49
Europe	1,906	1,841	4,713	4,821
Oceania	3	5	5	83
U.S.S.R.	-	145	-	267

Source: FAO Yearbook of Forest Products 1980.

Table 3.46 Largest imports and exports of particle board in 1980
Volume in 1,000 m^3

Rank	Imports		Exports	
	Country	Volume	Country	Volume
1.	U.K	1,280	Belgium-Luxemb.	1,164
2.	Germany, Federal Rep.	971	Austria	675
3.	U.S.A.	538	Germany, Fed. Rep.	660
4.	Netherlands	529	Sweden	468
5.	Italy	483	Finland	374
6.	France	386	France	372
7.	Germany, Dem. Rep.	180	Spain	281
8.	Poland	169	U.S.S.R.	267
9.	Denmark	135	Switzerland	247
10.	Belgium-Luxembourg	111	Romania	230
	Total	4,782	Total	4,738

Source: FAO Yearbook of Forest Products 1980.

Table 3.47 Trade in fibreboard by regions
1970 and 1980
Volume in 1,000 m^3

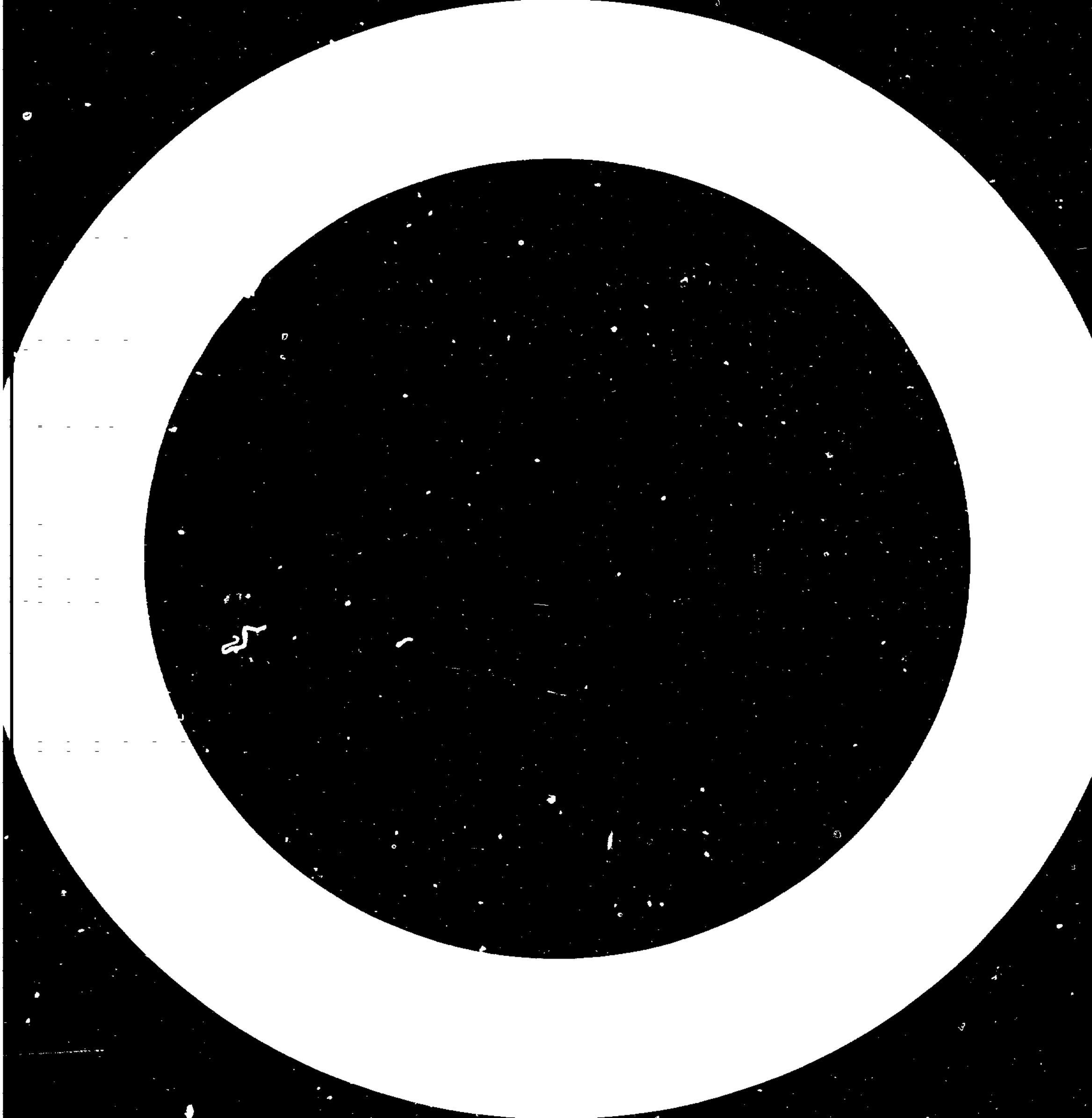
Region	1970		1980	
	Imports	Exports	Imports	Exports
World	2,067	2,062	1,887	2,133
Africa	66	71	100	24
North America	319	187	254	267
Central America and Caribbean	10	1	8	2
South America	11	45	5	186
Asia	63	13	98	24
Europe	1,569	1,552	1,416	1,302
Oceania	28	55	6	25
U.S.S.R.	-	139	-	303

Source: FAO Yearbook of Forest Products 1980.

Table 3.48 Largest imports and exports of fibreboard in 1980
Volume in 1,000 m^3

Rank	Imports		Exports	
	Country	Volume	Country	Volume
1.	United Kingdom	316	U.S.S.R.	303
2.	Germany, Federal Rep.	301	Sweden	280
3.	U.S.A.	183	U.S.A.	200
4.	Netherlands	132	Brazil	147
5.	Italy	127	France	138
6.	France	125	Finland	119
7.	Poland	98	Spain	118
8.	Germany, Dem. Rep.	76	Poland	92
9.	Belgium-Luxembourg	75	Austria	72
10.	Canada	71	Romania	67
	Total	4,782	Total	4,738

Source: FAO Yearbook of Forest Products 1980.



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