**ASIA-PACIFIC FORESTRY SECTOR OUTLOOK STUDY**

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# ASIA PACIFIC FORESTRY SECTOR OUTLOOK: FOCUS ON COCONUT WOOD

by

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## INFORMATION NOTE ON ASIA-PACIFIC FORESTRY SECTOR OUTLOOK STUDY

At its sixteenth session held in Yangon, Myanmar, in January 1996, the Asia-Pacific Forestry Commission, which has membership open to all governments in the Asia-Pacific region, decided to carry out an outlook study for forestry with horizon year 2010. The study is being coordinated by FAO through its regional office in Bangkok and its Headquarters in Rome, but is being implemented in close partnership with governments, many of which have nominated national focal points.

The scope of the study is to look at the main external and sectoral developments in policies, programmes and institutions that will affect the forestry sector and to assess from this the likely direction of its evolution and to present its likely situation in 2010. The study involves assessment of current status but also of trends from the past and the main forces which are shaping those trends and then builds on this to explore future prospects.

Working papers have been contributed or commissioned on a wide range of topics. They fall under the following categories: country profiles, selected in-depth country or sub-regional studies and thematic studies. Working papers are prepared by individual authors or groups of authors on their own professional responsibility; therefore, the opinions expressed in them do not necessarily reflect the views of their employers, the governments of the Asia-Pacific Forestry Commission or of the Food and Agriculture Organization. In preparing the substantive report to be presented at the next session of the Asia-Pacific Forestry Commission early in 1998, material from these working papers will be an important element but will be blended and interpreted alongside a lot of other material.

Working papers are being produced and issued as they arrive. Some effort at uniformity of presentation is being attempted but the contents are only minimally edited for style or clarity. FAO welcomes from readers any information which they feel would be useful to the study on the subject of any of the working papers or on any other subject that has importance for the Asia-Pacific forestry sector. Such material can be mailed to the contacts given below from whom further copies of these working papers, as well as more information on the Asia-Pacific Forestry Sector Study, can be obtained:

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## 1. INTRODUCTION[1]

The coconut palm (*Cocos nucifera, L.)* has multifarious uses. It is often described as a tree of life and is one of the most important crops in the tropics. It is also considered as one of the world's most beautiful trees. Practically all parts of the coconut can be manufactured into commercial products. The coconut provides food, shelter and fuel especially in countries in Asia and the Pacific where it is abundantly grown.

Unlike the many uses of the coconut fruits and the leaves, it is perhaps not very well known that the coconut stem is equally useful. Annex 1 gives some characteristics of the tree and its wood relevant to utilization. The possibility of utilizing the coconut palm wood on a commercial scale has been recognized only in the last decade or so, although usage of wood from palm species has been known by people in the villages since time immemorial. In more recent times, coconut palm wood has been successfully utilized in a number of coconut growing countries such as the Philippines, Indonesia, Sri Lanka, Fiji, the Tonga Islands and many others.

It has been used in boat making in many islands in the Pacific. Relatively large and elaborate church structures and roof components have been constructed early in this century from round or hewn coconut palm wood, and these materials are reported to be still in good condition. These roof structures have been reported to have survived many tropical high wind storms including the hurricane "Isaac" (Tonga Islands) in 1982 which was responsible for considerable damage to many contemporary buildings.

As a result of the heavy reliance on utilization of traditional wood species without adequate provision for resource renewal, the wood-using industry now faces scarcity and prohibitive cost of conventional wood. The need to look for lesser-known indigenous wood material that can be used as a good substitute for commercially-known wood species to overcome the inadequate supply of logs and at the same time help conserve the remaining forests led to a serious consideration of the many uses of the coconut trunk.

The growing number of old and senile palms in coconut growing countries especially in Asia and the Pacific necessities large-scale replanting. In some countries, the occurrence of strong hurricanes usually fells thousands if not millions of coconut trees on a yearly basis. Still in other countries, the move towards urbanization or coconut plantations being transformed into residential areas requires the cutting of coconut trees and thus, necessitates efficient utilization of the trunks[2].

It has been widely recognized that the most effective way of disposing the felled trunks is to convert them to saleable wood products which not only provides a system of proper disposal

[1] Mr. Romulo N. Arancon, Jr. is currently the Assistant Director of the Asian and Pacific Coconut Community (APCC) based in Jakarta, Indonesia. Mr. Arancon was formerly the Department Manager of the Coconut Extension and Training Centre of the Philippine Coconut Authority (PCA). He has also served as a Co-Training Director of the UNDP/FAO project (RAS/81/110) “Regional Coconut Wood Training Programme” at the PCA-Zamboanga Coconut Wood Research Centre, Philippines. This document has been significantly restructured by the editor but great efforts have been made to retain the original message.

[2] When old palms are felled, proper disposal of the trunks should be done. Otherwise, if they are allowed to rot in the field, they would serve as breeding places for beetles which would ultimately create serious infestation problems to the newly - established coconut palms.

but can generate employment and give an additional source of income in coconut producing countries. Furthermore, coconut wood utilization can supplement the supply of raw materials for the wood industry and provide low-cost but equally durable construction materials for the housing programmes in these countries and for export.

Cognizant of the value of the coconut trunk as a wood resource with various applications, efficient coconut wood utilization technologies have been developed by a number of research institutes in Asia and the Pacific. The main purpose of this paper is to make an assessment of the existing and potential resources of coconut wood in the Asia-Pacific region with focus not only on resource availability trends but also on the technologies and facilities that are available for efficient coconut wood utilization and the driving forces that affect them. The paper will also describe and analyse the current situation as well as the prospects of utilization and marketing of cocowood products in the region highlighting on the value that could be added by processing coconut wood and the actual as well as the potential financial and social impact such operations could bring to the region.

## 2. RESOURCE INVENTORY

### *Regional Overview*

#### Magnitude of resource and potential yields

The coconut area in the Asia and Pacific region is presented in *Table 1.* The estimated coconut area with senile palms as well as the estimated number of senile trees and the projected number of senile trees available for cutting up to year 2015 or beyond are also presented in *Table 2.*

Indonesia and the Philippines followed by India, Papua New Guinea and Thailand showed large areas with senile palms which are no longer productive and are therefore due for cutting or replanting. Indonesia as well as some of the Pacific Islands (Fiji, Micronesia, Papua New Guinea and Vanuatu) have 50 to 60% of their coconut area with over-aged or senile palms. Among the Pacific countries, Papua New Guinea, Vanuatu and Fiji have quite large numbers of coconut trees that need replanting with so much trees that could be processed into coconut wood.

With Indonesia's estimate of about 50% over-aged palms, the country has a coconut wood resource of approximately 185.6 million senile trees which could be cut down and replaced with hybrids and other high yielding varieties. Based on a sawn lumber recovery of 0.30 cubic meter per tree, around 55.7 million cubic meters of sawn wood are available for economic utilization. Assuming that the sawn lumber shall be used for the construction of a typical 60-square meter, 2-bedroom low cost house with a lumber requirement of 15 cubic meters per house, a total of 3.71 million housing units could be constructed out of these wood materials. And if this cocowood resource were spread in a 40-year replanting cycle, still a yearly cocowood resource of 4.64 million senile trees or 1.4 million cubic meters of sawn wood would be available yearly in the next 40 years for economic utilization. This cocowood resource could be used to build some 93,000 housing units per year.

In the Philippines, where coconut wood is becoming widely used in house construction, a cocowood resource of 95 million senile trees would give 28.5 million cubic meters of sawn wood for economic utilization, or a potential of 1.89 million housing units.

The age of a coconut tree can be visually estimated by counting the leaf scars while the volume of the stem is derived in the usual manner from its height and diameter. A typical coconut farm is estimated to have 100 trees per hectare. Coconut wood resource assessment in a given/region area can be done by estimation of the percentage area considered over-mature or senile, the tree population per hectare, the replanting or felling rate per year and the wood volume per tree. Other methods of resource assessment involve actual survey in a given area or aerial photography.

It should also be noted that since coconut is basically a smallholder's crop, adequate incentives from government and appropriate policies on cutting and replanting senile and unproductive coconut trees must be in place. To make the resource available, coconut smallholders must be predisposed to cut and replant senile trees, given the necessary incentives, policy support end the required facilities and infrastructure. The investment both from government and the private sector necessary to enable productive use of this resource would certainly use of this resource would certainly contribute to better employment, and additional income for the coconut smallholders and overall economic development in coconut growing countries.

Further details concerning specific countries in Asia and in the Pacific follow below.

**Supply**

Totalling the country level availability reported in the sections which follow, the whole Asia-Pacific region has an estimated number of senile trees of about 371.3 million or 111.4 million cubic meters of sawn coconut wood. This coconut wood supply level would be enough to build a total of 7.4 million housing units. However, it must be noted that the actual availability of this resource depends on the magnitude of the replanting/coconut cutting programmes of the coconut producing countries in the region. These must be adequate incentives for coconut cutting/replanting in terms of income derived from the sale of logs, government and private sector assistance in actual logging operation and subsidies for the new planting of high yielding coconut varieties and hybrids.

Based on the Philippine experience, coconut cutting was greatly influenced by the price derived from the sale of the trunks. This led to the Philippine government's policy of regulating the cutting of coconut trees only in the case of senile, diseased and typhoon-damaged trees. The price of the trunks even encouraged smallholder coconut farmers to indiscriminately cut productive trees.

Coconut cutting or replanting in the many coconut producing countries in the Asia-Pacific region has been proceeding at a very slow rate per year, if at all. Some countries do not yet have an institutionalized coconut replanting programme. Given the necessary boost and with the provisions of adequate incentives, coupled with the pressure of a dwindling conventional wood resource, coconut cutting could proceed in a grand scale thereby making available a tremendously supply of coconut trunk for lumber.

## *Country information*

### Philippines

In the Philippines, coconut is mainly a smallholder crop. Coconut occupies 23% of the country's total land devoted to agricultural use. Major coconut producing areas are Southern Mindanao, Southern Luzon and Western Mindanao. It has been estimated that coconuts are grown in approximately 1.6 million coconut farms in which 71% of the landholdings are 5 hectares and below, and only about 3% are more than 50 hectares.

As of 1995, the total coconut area is estimated at 3.164 million hectares. Of these about 30% have already reached senility which consist mainly of palms that are 60 years old and over. Based on this estimate and with an average of 100 trees per hectare, the potential is for around 95 million unproductive and senile palms to be cut and replanted. On the basis of sawn timber recovery of 0.30 cubic meter per tree, a total of 28.5 million cubic meters of coconut lumber would be available for economic utilization. This raw material supply availability does not yet account for the thousands or millions of trees that may be felled due to strong typhoons. On the average, some 25 typhoons at varying intensities hit the Philippines annually.

### Indonesia

From approximately 1.8 million hectares in 1970, the coconut area in Indonesia has tremendously increased in the past two decades to 3.71 million hectares in 1995. Coconut area represents around 26% of the entire plantations in Indonesia. Around 95% of the country's coconut area is situated in the islands of Sumatra, Java, Sulawesi, Kalimantan, Nusa Tenggara, and Maluku. Sumatra accounts for some one-third of total coconut cultivation. In the 1970's, coconut growing was 99% smallholdings. In the 1980's, share of smallholdings slightly declined to 97%, with 2% going to privately-owned estates and 1% to government-owned estates. Of the entire area under coconut, 93% is classified as holdings of less than 5 hectares. About 50% of the palms are senile and need replanting.

### India

The coconut area in India has increased from a little over 1 million hectares in the early 1970's to over 1.6 million hectares in 1995 and is anticipated to further increase to 2 million hectares by the year 2000. Coconuts are grown mainly along the coastal belts and some interior tracts. More than 90% of the area under coconut is concentrated in the Southern States of Kerala, Karnataka, Tamil Nadu and Andra Pradesh. Kerala accounts for 55% of India’s total coconut area. Coconuts are mainly grown by smallholders with 98% of the holdings of size less than 2 hectares. About 20% of the palms are both senile and unproductive, and therefore need replanting.

## Malaysia

Coconut ranks fifth in Malaysia's agriculture in terms of cultivated area with oil palm and rubber occupying the greater portion. The coconut industry, however, still plays an important role in the country's economy providing livelihood to some 100,000 farm families or almost 10% of the nation's farming community.

In terms of area planted, the highest level was attained in 1982 at 363,000 hectares. Since 1986 at 330,000 hectares, the area planted to coconut was observed to be at a generally decreasing trend reaching to 315,000 hectares level in 1992 and down to 290,000 hectares in 1995.

Coconut in Malaysia is generally a smallholder's crop with 91% under smallholder cultivation and 9% under estate management. Of the total area planted to coconut, 63% is located in Peninsular, Malaysia, 19% in Sabah and 18% in Sarawak. With increasing labour shortage, decreasing productivity of palms and the massive conversion of coconut lands to oil palm plantation and other more profitable crops, the country projects a continuous decline in coconut area at a rate 0f 2.5-3.5% per year to some 285,000 hectares towards year 2000. It was estimated that about 32% of the total plantings are now well over 60 years old.

## Sri Lanka

Coconut accounts for the second largest land usage in Sri Lanka with about 25% of the total arable land. As a major commercial crop in the country, the coconut industry provides employment to some 135,000 people involved in the production, processing, and trading sectors of the industry.

The period from 1970 to 1995 saw a gradual decline in area under coconut, from 466,000 hectares in 1970 to 419,000 hectares in 1995. This gradual decline in area under coconut which involved cutting of coconut palms was due to the increasing use of coconut land for urbanization, industry and housing programmes.

Coconut in Sri Lanka is largely under private ownership with a vast majority classified as smallholding of less than 1.2 hectares. The percentage of palms over 60 years of age was estimated at about 15% of the total plantings.

## Thailand

Most of the coconut areas in the country are found in the peninsular provinces or on the shores of the Gulf of Thailand accounting for 80% of total planted area. Coconut farms in Thailand are primarily of the smallholder type with a mean farm size of 2.4 hectares, 80% or more of the holdings being less than 2 hectares.

In the period 1970-1992, the coconut area ranged between 320,000 and 412,000 hectares and is expected to remain stable up to year 2000. The country estimates the present age structure of coconut palms at 60% of the population between 15 and 40 years old, 10% immature or non-bearing and the remaining 30% mainly senile palms. Typhoons also hit the prime coconut producing areas in Southern Thailand and at times cause massive felling of trees. Some of the country's coconut area are also converted into the production of other more profitable crops or into housing development projects.

## Vietnam

The coconut industry in Vietnam contributes to the economic welfare of some 10 million Vietnamese, and provides direct employment to some one million people. In 1957, the country had 31,540 hectares planted to coconut which increased to 40,800 hectares in the early 60's. Due to war damage, coconut area decreased to about 35,000 hectares in the early and mid 1970's. The area under coconut henceforth increased reaching a peak of 350,000 hectares in 1990 and has drastically declined to some 186,000 hectares in 1995. The decline in area was due to the shift in land use from coconuts to fruit trees.

Of the total area under coconut, 73% is located in the 9 provinces of the Mekong delta. As a matter of national land policy, private coconut holdings in Vietnam are limited to 0.5 hectares or less, with 60% smallholders, 30% cooperatives and 10% state farms. Since nearly 65% of the area under coconut has been planted after 1983, the majority of the palms are relatively young; senile palms are estimated to be about 10%.

## Federated States of Micronesia

The Federated States of Micronesia has a total land area of 66,551 hectares of which 17,000 hectares are planted to coconut. There are no large plantations, only smallholders with an average farm size of less than 2 hectares. A substantial decrease in coconut area occurred in the last two decades from 30,000 hectares in 1970's to 17,000 hectares in the 90's. This decreasing trend in coconut area is a result of substantial conversion of coconut lands to the production of other crops especially in the State of Kosrae and conversion to housing facilities in the State of Chunk. The existing coconut stands are mainly already senile (60%) or have reached 60 years or more and are therefore due for replanting.

## Fiji

The coconut area in Fiji has gradually declined from 78,000 hectares in 1978 to 64,000 in 1995, of which 60% or approximately 39,000 hectares are already senile or over-mature and are therefore due for replanting. Fiji's current coconut replanting/cutting programme is about 5,250 hectares until year 2000. This means an annual rate of about 1,313 hectares per year. There is only one coconut wood processing plant in Fiji called the Pacific Green Industries. Currently its absorption capacity is at 700 logs per week. It is however willing and capable of increasing its absorption capacity to 100,000 logs per year. Logs are bought on the farm at US$6.00 each, that is at 8ft x 8" diameter. These logs are only made into furniture for the local and export markets.

## Papua New Guinea

Coconut occupies about 6% of the country's total land area. Of the total coconut area, smallholder cultivation (less than 5 hectares) accounts for about 6%. From 1970 to 1979, coconut area was maintained at about 265,000 hectares. Currently there are 260,000 hectares of coconut land in PNG, of which 50% of the total plantings are estimated to be senile and unproductive and therefore need replanting.

## Solomon Islands

Area under coconut in Solomon Islands is recorded at 59,000 hectares with a total tree population of about 9 million. Total coconut area is projected to remain stable until year 2000. Of the total coconut area, 65-85% is classified under smallholding with an average of 2.5 hectares per holding. The age structure of the palms is relatively young with about 50% of the existing stands under smallholder cultivation planted in the 1970's. A sizeable area of coconuts was also planted after the second world war. It is estimated that some 20% of the plantings are senile.

## Vanuatu

Coconuts in Vanuatu occupy some 96,000 hectares or roughly 66% of total land under agricultural use or 18% of the country's total arable land. Of the total plantings, some 20% are under plantations and 80% are under smallholdings, with the steady increase in smallholdings observed towards the 90's. There has been a substantial increase in coconut area from 61,000 hectares in 1970 to 96,000 hectares in 1995. At an annual average increase of 3%, coconut area is expected to be in the vicinity of 120,000 hectares by year 2000. It was estimated that only 7% of plantation coconuts were under 30 years old and about 50% of the plantings are already senile and unproductive. Replanting rate is reported to be at 2.7% per annum especially among smallholders.

## Western Samoa

The coconut area in Western Samoa has gradually increased since 1970 from 28,000 hectares to a peak of 50,000 hectares in 1987. Since then, the total coconut area slightly decreased due to land conversion and cyclones damage but has now increased to 75,000 hectares through replanting and new planting. More than 80% of the coconut farms are based on landholdings with an average area per holding of 3.64 hectares. The country is also hit by cyclones, the more devastating ones were OFA in 1990 and VAL in 1991, felling thousands of coconut trees. It is estimated that about 16% of the total plantings are 60 years old or over and considered senile.

## 3. USES OF COCONUT WOOD AND MARKETS

### *Use in construction*

One of primary uses of coconut timber is for building construction. Coconut timber is suitable for housing components like trusses, purlins, walls, joists, doors, window frames and jalousies. Low density coconut wood materials (from the centre of the stem) should be used only in non-load structures like walls and panels while high density coconut wood (from the perimeter of the stem) can be used for load-bearing structures like trusses and joints. *Table 6* could serve as a guide for prospective users of coconut timber for building construction. *Table 7* lists the different coconut timber derived products and the recommended characteristics of raw materials to use.

The small diameter of coconut stem limits the size of sawn lumber, hence the optimum width and thickness of boards that are usually recovered are 25mm and 50mm, respectively. For structures requiring bigger sizes of lumber, glued lamination of the wood to the desired dimensions solves this particular problem.

High density coconut wood could also be used as posts, power and telecommunication poles, trusses, floor tiles (parquet), girts, floor joists, purlins, balustrades and railings and other load bearing structures. When coconut logs are to be used in ground contact under exposed conditions (e.g. as posts or as poles for electrical wires) they must be properly treated.

Medium density boards can be effectively used for walling, horizontal studs, ceiling joists and door/window frames. As a rule, coconut wood with density below 400 kg/m3 should not be used as structural framing materials. However, they can be used in the internal parts of a building as ceiling and wall lining in the form of boards and shingles. A problem related to structural application of cocowood is the difficulty of nailing and subsequently splitting of high density wood finishes.

### *Use in Furniture and high-value products*

Coconut wood can be a promising material for the manufacture of furniture, novelties and other handicrafts due to its beautiful grain and attractive natural appearance. High value coconut wood products which include furniture, decorative interior walls, parquet floors, various novelties and curio items like walking sticks, ash trays, hammer handles, egg cups, plates, bowls, vases, etc. are equally, if not more than, comparable to the traditional wood species commonly used in the furniture industry as far as appearance is concerned. Hence, with effective product promotion, quality furniture and other high value coconut wood products can have a potential share not only in the domestic but also in the world markets.

Coconut wood has potential for the manufacture of high value and export-quality finished products. However, like many other conventional wood species untreated freshly-cut lumber can be easily attacked by mould and staining fungi especially if the material is not properly stacked and is exposed to humid environment during the air drying process. Further degradation during air drying can also be caused by decay fungi and pinhole borers. Hence, prophylactic treatment is necessary if it is used for the production of high value products for export.

Checks and cracks develop on the surface of improperly dried coconut wood or in response to variation of relative humidity; hence kiln drying should be done to bring its moisture content to the level most appropriate for equilibrium with its location in service.

### *Charcoal*

Coconut trunk and other sawmill residues are readily usable for charcoal making and for the production of energy. Coconut wood is similar to other woods in its characteristics as fuel, although the range of densities within the stem leads to variation in the energy potential.

Studies using the 2-cord double walled masonry block kiln showed the production of good quality charcoal for domestic use at an average yield of 25% based on the oven-dry weight. Charcoal and charcoal briquettes have higher heating value. They are easily handled and produce less smoke compared to wood.

For fuel purposes, coconut trunk charcoal must be converted into briquettes to increase its strength and density as well as to improve its shipping properties. A technology for briquetting coconut trunk charcoal has already been developed. A briquetting plant in the Philippines produces ovoid type briquettes of 1.5 oz size at 500 lb/hr. The briquettes have good crushing strength and burning properties. Sorghum grain is an effective binder for charcoal briquettes of coconut trunk.

### *Chemicals*

Activated carbon can also be made from coconut trunk charcoal. The product can be a reliable source of carbon for the manufacture of various chemicals such as carbon disulphide, calcium carbide, silicon carbide, carbon monoxide, paint pigments, pharmaceuticals, moulding resins, black powder, electrodes, catalyst reactor, brake linings, and gas cylinder absorbent. Ethanol can also be produced from coconut waste products.

## *Market Profile*

The construction industry provides the bulk of the demand for coconut lumber. In the construction of big buildings, coconut lumber is used in large volumes as scaffolding and as form lumber. Selected and graded coconut lumber is also used as house posts, girders, trusses, door jambs and sidings. It has also been proven to be a suitable material for pallets. In the Philippines, a significant volume of coconut lumber was used in the government's low cost housing programme, as well as in other government buildings and various resorts throughout the country. This involves some 1.0 to 2.0 million cubic meter of coconut lumber annually.

Field observations could indicate that demand for coconut lumber is increasing. One indicator is the increase in the number of coconut lumber producers and dealers. Another indicator of rising demand in the increasing price trend of coconut trees. Ten years ago in the Philippines, coconut trees could be had for free. In 1995, one trunk was priced as high as ₱800 (US$29.00) depending on accessibility or nearness to highway or buying/processing centre and the quality of the trunks. The usual buying price in the Philippines could be pegged at a national average of ₱500 per trunk (US$15.00) with the buyer doing the logging operation, handling and transport. In Fiji, coconut logs of 8ft x 8" diameter are bought on the farm at US$6.00 each.

When compared to the local mainstream lumber species, coconut wood has a remarkably lower price. Philippine data reveal that the commercial hard wood apitong (Dipterocarpus grandiflorus) would cost P 38.00 (US$1.38) per board foot (bd. ft.) as compared to ₱ 8.00 (US$0.29) per bd. ft for coconut lumber. Tanguile (Shorea polysperma), a common commercial wood of lesser basic density as apitong is still comparatively much higher in price than cocowood, at ₱ 26.00 (US$0.95) per bd. ft.

## *Demand*

The actual and potential demand for coconut wood could be derived from actual and projected needs for housing, the construction of big high-rise buildings, electrical and telecommunication poles, poultry and other livestock buildings, grocery pallets, and demand for house/office furniture, novelty items and curious for both the domestic and export markets within and outside the Asia-Pacific region.

*Table 11* shows the potential demand for coconut lumber based on the housing requirements of 1% and 5% of most of the Asia-Pacific countries, respectively. With an estimated population in coconut growing countries in Asia and the Pacific of about 1.5 billion people and assuming that 1% of the population would need housing facilities, made from coconut wood, some 15 million housing units would then be required, equivalent to demand for some 226 million cubic meters of coconut wood assuming that one housing unit would require at least 15 cubic meters of coconut wood. Some 75 million housing units would be required if one assumes that 5% of the present population would immediately need coconut-based housing facilities. This requirement would create a demand of some 1.132 billion cubic meters of coconut wood.

It may be noted that even at 1% level, the demand of coconut wood for housing within the coconut growing countries in the Asia-Pacific region would exceed the supply. Thus, for housing needs alone, cocowood could have a big demand. The demand of coconut wood for other uses, e.g. construction of high rise buildings, furniture, novelties, etc., would have to compete for the demand of the wood for basic housing units.

The demand for coconut lumber in the construction industry is in the form of scaffoldings and form lumber. The construction industry, a vital industry in stimulating economic growth, is currently developing at a fast pace in many centuries in Asia and the Pacific creating an increasing demand for coconut lumber. The growth in tourism in the region and the economic development of the Pacific rim are perceived to contribute to the increasing trend in demand for cocowood novelty items, curious, and similar items. Europe and the North American countries have been observed to have gained a liking for coconut wood furniture and other small and inexpensive novelty items considering its natural sensuous beauty, attractive clear-grained appearance and lasting integrity.

## 4. ECONOMICS OF COCONUT WOOD UTILIZATION

Coconut wood has proven to be comparable to conventional wood in terms of durability, sturdiness, and versatility often at a considerably lower cost. The use of cocowood as a substitute material for building construction could bring down the cost of housing units. This is because its cost is half or a little more than half the price of conventional wood.

The key to profitability in the utilization of coconut wood, given availability of raw material supply and product demand, is the mechanical conversion of coconut logs into lumber. The mechanical methods of primary conversion of coconut logs into lumber are the chainsaw, the mounted portable and stationary sawmills. The preference of using chainsaw over mounted portable or stationary sawmills is its low investment cost and complete portability by a single operator. Mounted portable sawmills, although could be operated near the raw material source, require a number of personnel. The use of stationary sawmills or portable ones, although efficient in terms of lumber recovery, is as yet very limited because of prohibitive initial investment in putting them up coupled with the perceived irregularity of raw material supply availability which may delay the recovery of investment and the desired profit.

### *Coconut Lumber Production*

It should be emphasized that an essential pre-requisite for the establishment of a coconut wood industry is an assurance of an adequate supply of over mature or otherwise disposable stems of known volume. A precise estimate of the availability of the raw material must be made if industrial investment is contemplated.

Coconut lumber production among smallholders' is usually done by chainsaw. In the Philippines where a significant number of cocowood lumber producers and sellers are operating on a small scale, coconut lumber is usually produced by a team who cut the coconut trees and saw the logs by the use of chainsaw. These operators either sell the lumber to a lumber yard owner or sell them directly to big buyers. The cost of coconut lumber manufacturing by chainsaw per crew per day at material source is broken down as follows (case study based in the Philippines):

| **Cost Components** | | **Per Cent Distribution** |
|---|---|---|
| 1. | Raw Material Cost of Coconut Trunk | 54% |
| 2. | Hired Labour: | |
| | - One Chainsaw Operator | 17% |
| | - Two Helpers | 9% |
| 3. | Full/Lubricant | |
| | a. 8 litres gasoline | 4% |
| | b. 3 litres oil | 8% |
| 4. | Equipment Depreciation | |
| | -chainsaw | 2% |
| 5. | Replacement/Maintenance of Chainsaw Parts | 6% |
| | | 100% |

Assumptions:

- No of trunks processed = 5 logs per day
- Gross volume = 4.5 cu.m
- Average Diameter = 22 cm
- Lumber Recovery Per Log = .30 cu.m
- Chainsaw Unit owned by chainsaw operator
- Excludes transportation cost as distance of plantation to lumber yard varies

A Chainsaw-Table Saw Coconut Lumber Manufacturing System and Preservative Treatment by Soaking Method exists for which the technology has been commercialized since 1988 (developed in the Philippines). It has been proven to be economically feasible with an ROI of 32%.

Experience shows that sawmilling is the most difficult aspect in the processing of coconut stems. Sawing of coconut trunks is more efficiently done by portable sawmills. As in the case of Tonga, the Philippines and other countries, where adequate supply of senile trees are available for cutting and where the market can absorb the lumber produced, portable sawmills with an output capacity of 1.6 cu.m per day (5 hours per day) are being deployed. These sawmills are specifically designed to coconut wood. Power unit can be either a stationary motor or a tractor. The latter is much preferred as it increases the portability of the sawmill. Tractor driven sawmill requires only 3 operators to do both harvesting and milling. The two operations can be programmed so that one activity can be done in a certain day(s) of the week. In this way all labour, harvesting and milling facilities are fully utilized throughout the year. The system requires only a standard tractor fitted with lifting forks; one chainsaw, and a one piece portable sawmill fitted with a single detachable axle.

In isolated districts where senile palms are abundant but the hauling distance is becoming too far to the stationary sawmill and or the market place, portable sawmills with an output capacity of 3-4 cu.m per day can be deployed to support the central stationary sawmill. Once again the choice of power unit is optional. The type that is used in Tonga comes in 3 pieces; the power unit is optional. The type that is used in Tonga comes in pieces; the power unit with its own set of wheels; the breakdown saw and a separate breast bench. Both saws are attached to the power unit with shafts. Only 5 labourers are required to operate the sawmill.

The total cost for producing one cubic metre of sawn timber would have the following approximate cost components: 50% is represented by the cost of buying and delivering logs to the mill, while the other 50% consists of the following cost items:

| | |
|---|---|
| Labour | 34.32% |
| Power | 6.86% |
| Repairs & Maintenance | 7.84% |
| Sawblade maintenance | 8.82% |
| Loading/handling | 5.88% |
| Depreciation | 11.76% |
| Overhead | 24.52% |
| Total | 100.00% |

The indicative cost of the different equipment and machinery being utilized commercially in the harvesting and sawmilling of coconut trunks as well as in the preservative treatment of coconut wood are as follows:

| **Equipment/Machinery** | | **Indicative Cost*** |
|---|---|---|
| Harvesting | | |
| 1. | Chainsaws (standard) | US$500/unit |
| 2. | 20 ton tip trucks (6x4) (flat-dock) | US$90,000-120,000/unit |
| 3. | Front-end loader (4x4) (2.5 tonne lift capacity) | US$70,000-90,000/unit |
| Sawmilling | | |
| 1. | 3 x Edwards Stationary Sawmills in Two Parts<br>(i) Headrig Saw (circular) with log carriage, by 75hp motor.<br>(ii) Breast bench (circular) manually operated by 35hp motor. | US$170,000 |
| 2. | Tractor loader (standard) | US$ 20,000 |
| 3. | 1 x Varteg portable sawmill Driven by tractor<br>P.T.O. Single circular saw output capacity:<br>1.6m$^3$/day; operators: 3 | US$ 25,000 |

| Equipment/Machinery | | Indicative Cost* |
|---|---|---|
| 4. | 1 x Varteg portable sawmill driven by stationary 47hp engine break down saw<br>(i)Engine<br>(ii)Breakdown saw<br>(iii)Breast bench<br>Output Capacity: 3-4m3/day operators: 5 | US$ 35,000 |
| 5. | Breaking down resaw unit, suitable for Village use. Production 1-3 cubic meters per day. | US$11,300 |
| 6. | Breaking down and Breast bench, suitable for light contracting. Production 4-5 cubic meter per day. | US$24,700 |
| 7. | Contracting model Breaking down and Breast bench, and log loading forks fitted and driven by a 60-80Hp. Diesel engine, fitted with all accessories, mounted on a trailer unit. Production, up to 10 cubic metres per day | US$30,500 |
| Preservative Treatment | | US$250,000 |
| 1. | Pressure Treatment Plant<br>Charge capacity : 7m$^3$<br>Cylinder length : 37 feet. | |

* Based on data from Tonga and New Zealand Sawmill Manufacturers.

## 5. PROSPECTS OF COCONUT WOOD UTILIZATION AND COMMERCIALIZATION

There is substantial evidence to argue that coconut wood utilization and commercialization have considerable potential in the immediate future and in the long term. This scenario is driven by several factors. First, in many countries in Asia, the availability of preferred tropical hardwood has declined dramatically in recent years, especially in areas with high population density. Second, the extensive stands of senile and unproductive coconut trees in the Asia-Pacific region will have to be cut and replaced by high yielding varieties to sustain the coconut industries in these countries which often constitute a pillar of their rural economies. The coconut replanting programmes in all coconut producing countries within the region would certainly release huge volumes of raw materials for utilization. Third, coconut wood processing technologies have been developed, and appropriate machinery and equipment have been developed to enable efficient commercial operation on coconut wood utilization.

From the economic and environmental point of view, it is practical to process and add value to a potentially useful resource rather than see it go to waste and pose a hazard to the environment. From the forest conservation perspective, increased used of coconut wood could potentially reduce the pressure exerted on natural forests by providing alternative or complementary raw material for housing, building construction and other uses. There is also significant prospects for income and employment generation to be derived from increased utilization of coconut wood. This prospect is both socially and economically attractive since more than 80% of coconut landholdings in the Asia-Pacific region are owned by small farmholders.

The demand for coconut wood for housing is very high in view of the fast growing population in the region. Tourism and the economic boom in the Pacific rim could also provide an increasing demand for coconut wood products in the form of furniture and other novelty items. Since the market is price driven, small but inexpensive and easy to sell cocowood items will find their way in the marketplace not only within the region but in European and North American countries. The environmental concern of most people in the world could create a push for an easily renewable resource like coconut wood. The idea of substituting the cutting of a forest tree with products derived from coconut lumber should fit well into the thinking and feelings of environmentally - friendly people world-wide.

The increasing trend of demand for coconut wood could very well follow the success achieved in the utilization and commercialization of rubberwood and even wood derived from mango trunks. After resolving the technological problems and constraints on raw material supply availability, rubberwood is now the raw material of choice for the Malaysian and Thai furniture industry.

To sustain the utilization and commercialization of coconut wood, it is therefore necessary that the governments and the private sector consider the following:

- ensure adequate raw material supply availability on a continuing and sustained basis;
- maintain active research programme to overcome technical problems and expand product lines;
- support the training of potential sawmillers and other users to build confidence in the material and create a critical mass of investors and entrepreneurs in the coconut wood industry; and
- support a private sector led promotional campaign to convince all players in the industry and its potential users and consumers on the versatility of coconut wood.

***Table 1 - Asia and Pacific: Coconut Area, 1991-1995 (in 1000 Ha)***

| Country | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|
| A.APCC member Countries | 10,071 | 10,105 | 10,090 | 10,272 | 10,437 |
| Asia | 9,533 | 9,548 | 9,529 | 9,706 | 9,852 |
| India | 1,514 | 1,529 | 1,538 | 1,635 | 1,669 |
| Indonesia | 3,573 | 3,599 | 3,636 | 3,681 | 3,712 |
| Malaysia | 320 | 315 | 310 | 305 | 290 |
| Philippines | 3,093 | 3,077 | 3,075 | 3,083 | 3,164 |
| Sri Lanka | 419 | 419 | 419 | 419 | 419 |
| Thailand | 389 | 389 | 336 | 397 | 412 |
| Vietnam | 225 | 220 | 215 | 186 | 186 |
| Pacific | 538 | 557 | 561 | 566 | 585 |
| F.S. Micronesia | 17 | 17 | 17 | 17 | 17 |
| Fiji | 56 | 65 | 65 | 65 | 64 |
| Papua New Guinea | 260 | 260 | 260 | 260 | 260 |
| Solomon Islands | 59 | 59 | 59 | 59 | 59 |
| Vanuatu | 96 | 96 | 96 | 96 | 96 |
| Western Samoa | 36 | 46 | 50 | 55 | 75 |
| Palau | 14 | 14 | 14 | 14 | 14 |
| B.Other Countries | 111 | 111 | 109 | 109 | 109 |
| Asia | 63 | 63 | 64 | 64 | 64 |
| Bangladesh | 31 | 31 | 31 | 31 | 31 |
| Myanmar | 29 | 29 | 30 | 30 | 30 |
| Others | 3 | 3 | 3 | 3 | 3 |
| Pacific | 48 | 48 | 45 | 45 | 45 |
| French Polynesia | 5 | 5 | 5 | 5 | 5 |
| Kiribati | 26 | 27 | 25 | 26 | 25 |
| Others | 17 | 16 | 15 | 15 | 15 |
| Total | 10,182 | 10,216 | 10,199 | 10,381 | 10,546 |

*Source: APCC Statistical Yearbook 1995*

*Table 2: Cocowood Resources in Asia and Pacific*

| Country | Coconut Area: 1995 ( in '000 Ha) | Estimated Area with Senile Palms (%) | Estimated Area with Senile Palms (in 000 Ha) | Est. No. of Senile Trees (in '000 Trees)* | Assumed Replanting Cycle (No. of years) | Est. No. of Trees Available per year (up to 2015 or beyond '000 trees) |
|---|---|---|---|---|---|---|
| **A.APCC member Countries** | 10,437 | | 3,691 | 369,100 | | 9,940 |
| Asia | 9,852 | | 3,438 | 343,800 | | 8,675 |
| India | 1,669 | 20 | 334 | 33,400 | 20 | 167 |
| Indonesia | 3,712 | 50 | 1,856 | 185,600 | 40 | 4,640 |
| Malaysia | 290 | | 93 | 9,300 | 20** | 465 |
| Philippines | 3,164 | 30 | 949 | 94,900 | 40 | 2,373 |
| Sri Lanka | 419 | 15 | 63 | 6,300 | 20 | 315 |
| Thailand | 412 | 30 | 124 | 12,400 | 20 | 620 |
| Vietnam | 186 | 10 | 19 | 1,900 | 20 | 95 |
| Pacific | 585 | | 253 | 25,300 | | 1,265 |
| F.S. Micronesia | 17 | 60 | 10 | 1,000 | 20 | 50 |
| Fiji | 64 | 60 | 38 | 3,800 | 20 | 190 |
| Papua New Guinea | 260 | 50 | 130 | 13,000 | 20 | 650 |
| Solomon Islands | 59 | 20 | 12 | 1,200 | 20 | 60 |
| Vanuatu | 96 | 50 | 48 | 4,800 | 20 | 240 |
| Western Samoa | 75 | 16 | 12 | 1,200 | 20 | 60 |
| Palau | 14 | 20 | 3 | 300 | 20 | 15 |
| **B.Other Countries** | 109 | | 22 | 2,200 | | 110 |
| Asia | 64 | 20 | 13 | 1,300 | 20 | 65 |
| Bangladesh | 31 | | | | | |
| Myanmar | 30 | | | | | |
| Others | 3 | | | | | |
| Pacific | 45 | 20 | 9 | 900 | 20 | 45 |
| French Polynesia | 5 | | | | | |
| Kiribati | 25 | | | | | |
| Others | 15 | | | | | |
| Total | **10,546** | | **3,713** | **371,300** | | **10,050** |

**Estimated at 100 tress per hectare*
*** Malaysia's current policy will not involve replanting but coconut area is on a decreasing trend and to be maintained at approx. 285,000 hectare-level /n the year 2000*
*Source: APCC Statistical Yearbook 1995.*
*APCC Coconut Industry Country Studies.*
*Personal Communications from country experts.*

***Table 3: Comparative physical properties of cocowood and some conventional wood***

| | Cocowood (*Cocos Nucifera*) | | | Apitong (*Dipterocarpus grandiflorus*) | White Lauan (*Pentacme concorta*) | Tanguile (*Shorea polysperma*) |
|---|---|---|---|---|---|---|
| Properties | Dermal | Sub-Dermal | Core | | | |
| **Moisture content** (%) | 87 | 182 | 356 | 83 | 85 | 88 |
| Basic Density (kg/m3) | 697 | 473 | 286 | 619 | 441 | 466 |
| Shrinkage (Green to Oven-dry) | | | | | | |
| Radial | 6.3 | 5.9 | 5.6 | 6.8 | 3.7 | 4.1 |
| Tangential | 6.6 | 6.1 | 5.8 | 12.7 | 7.5 | 7.7 |
| | | | | | | |

***Table 4: Mechanical and related properties of cocowood***

| | | Static Bending | | | Compression Parallel To Grain | | Compression Perpendicular To Grain | |
|---|---|---|---|---|---|---|---|---|
| Basic Density (Kg/A3) | Moisture Content (%) | Modulus Of Elasticity (MPa) | Modulus Of Rupture (MPa) | Stress At Proportional Limit (MPa) | Modulus Of Elasticity (MPa) | Maximum Crushing Strength (MPa) | Stress At Proportional Limit (MPa) | Impact Bending (N) |
| | 57 | 10,857 | 86 | 51.6 | 7,988 | 49 | 8.3 | 20.2 |
| 600 and above | 12 | 11,414 | 104 | 61.7 | 9,747 | 57 | 9.0 | 20.1 |
| | 107 | 6,880 | 53 | 30.4 | 5,151 | 31 | 2.8 | 18.3 |
| 400 to 599 | | | | | | | | |
| | 12 | 7,116 | 63 | 38.4 | 5,282 | 38 | 3.4 | 10.1 |
| | 240 | 3,100 | 26 | 13.1 | 2,287 | 15 | 1.3 | 8.4 |
| 250 to 399 | | | | | | | | |
| | 12 | 3,633 | 33 | 15.4 | 2,914 | 19 | 1.7 | 9.0 |
| | | | | | | | | |

***Table 5: Comparison of mechanical and related properties of cocowood with some common conventional wood in green condition***

| Property | Cocowood *(Cocos Nucifera)* | | | Apitong *(Dipterocarpus grandiflorus)* | White Lauan *(Pentacme concorta)* | Tanguile *(Shorea polysperma)* |
|---|---|---|---|---|---|---|
| | High Density | Medium Density | Low Density | | | |
| Static bending | | | | | | |
| Modulus of Elasticity (1000 MPa) | 10.9 | 6.9 | 3.1 | 12.9 | 9 5 | 10.4 |
| Modulus of rupture (MPa) | 86 | 53 | 26 | 62.2 | 51.9 | 56.7 |
| Stress at proportional limit (MPa) | 51.6 | 30.4 | 13.1 | 35.7 | 31.3 | 33.9 |
| Compression parallel to grain | | | | | | |
| Modulus of elasticity (1000 MPa) | 7.9 | 5.2 | 2.3 | 17.3 | 12.3 | 13.3 |
| Maximum crushing strength (MPa) | 49 | 31 | 15 | 29.5 | 25.5 | 27.2 |
| Compression perpendicular to grain | | | | | | |
| Stress at proportional limit(MPa) | 8.3 | 2.8 | 1.3 | 4.8 | 3.3 | 3.7 |
| Hardness | | | | | | |
| Side (KN) | 5.3 | 2.4 | 0.7 | 3.9 | 2.6 | 2.7 |
| End (KN) | 3.8 | 2.1 | 1.3 | 3.8 | 2.9 | 2.8 |

***Table 6: Uses of coconut timber for building construction***

| Uses | Portion of Coconut Timber |
|---|---|
| Posts | Solid - round form |
| Flooring | Hard |
| Trusses | Hard |
| Floor joists | Hard |
| Stairs and railings | Hard |
| Door panels | Hard |
| Rafters | Hard |
| Window jambs | Hard |
| Sidings | Hard with soft |
| Ceiling | Hard with soft |
| Jalousies | Hard with soft |
| Studs | Medium |
| Purlins | Medium |
| Roof shingles | Medium |
| Exterior walls | Medium |
| Panels | Soft |
| Interior walls | Soft |

***Table 7: Coconut timber derived products and recommended characteristics of raw materials***

| Products | Portion of Coconut Timber |
|---|---|
| Boxes | |
| Cigar boxes | Hard portion |
| Chest and jewel boxes | Hard portion |
| Crating and packing boxes | Hard with soft portion |
| Canes and sticks | Hard portion |
| Household implements | |
| Plates | Hard with soft portion |
| Bowls | Hard with soft portion |
| Cups | Hard with soft portion |
| Novelties | |
| Gavels | Hard portion |
| Handles | Hard portion |
| Glass holder | Hard with soft portion |
| Candle holder | Hard with soft portion |
| Paper weight | Hard with soft portion |
| Ink stand | Hard with soft portion |
| Pencil holder | Hard with soft portion |
| Ash tray | Hard with soft portion |
| Lampshade stand | Hard with soft portion |
| name plate | Hard with soft portion |
| Laminated baseball bat | Hard with soft portion |
| Flower vases | Hard with soft portion |
| Cloth hangers | Soft portion |
| Fixtures | |
| Show case | Hard portion |
| Moulding | Hard portion |
| Shelves | Hard with soft portion |
| Cabinet divider | Hard with soft portion |
| Parquet flooring | Hard portion |
| Balusters | Hard with soft portion |
| Headboards | Hard with soft portion |
| Drafting boards | Hard with soft portion |
| Radio and television cabinets | Hard with soft portion |
| Boat side planking | Hard portion |
| Street sign posts | Hard portion |
| Road guard rails | Round and half round forms |

***Table 8: Kiln drying schedule of 25 mm sawn coconut lumber***

| Moisture Content (%) | Dry Bulb Temperature (C) | Wet Bulb Temperature | Relative Humidity | Cumulative Drying Time (Days) |
|---|---|---|---|---|
| Green - 85 | 49 | 44 | 78 | 2 |
| 85 - 58 | 53 | 47 | 75 | 4 |
| 58 - 35 | 56 | 48 | 64 | 5 |
| 35 - 28 | 58 | 49 | 51 | 7 |
| 28 - 19 | 62 | 48 | 43 | 9 |
| 19- 12 | 60 | 43 | 40 | 10 |

***Table 9: Air and kiln drying schedule of 50 mm sawn coconut lumber***

| Moisture Content (%) | Dry Bulb Temperature (C) | Wet Bulb Temperature | Relative Humidity | Cumulative Drying Time (Days) |
|---|---|---|---|---|
| | | | | (Air drying) |
| Green - 64 | - | - | - | 14 |
| | | | | (Kiln drying) |
| 64 - 54 | 45 | 36 | 55 | 3 |
| 54 - 39 | 50 | 40 | 55 | 6 |
| 39 - 28 | 55 | 44 | 53 | 10 |
| 28 - 22 | 58 | 46 | 53 | 13 |
| 22 - 17 | 61 | 47 | 51 | 17 |
| 17 - 15 | 65 | 48 | 53 | 20 |

*Table 10: Recommended treating processes for coconut wood*

| Service Condition | Preservative And Concentration | Process And Treatment Schedule | Timber Condition | Retention (Klt/Cu.m.) |
|---|---|---|---|---|
| Ground Contact | CCA: 4 - 5% | Pressure :1st vacuum 45 min; pressure-120 min; 2nd vacuum-10 min. | Dry | 14 -18 |
| | | | | |
| Outdoor, not in contact with ground | CCA: 2% | Pressure: 1st vacuum-30 pressure-60.; 2nd vacuum-10 min. | Dry | 7 -12 |
| | | | | |
| Indoor, not in contact with ground | Pentachlorophenol 5% in Oil | Soaking/brushing Soak for 10 min. or brush for 3 coatings | Dry | 1.8 - 2.0 |
| | | | | |
| | Cuprinol: ready-mixed | Brushing: brush for 3 coatings | Dry | 1.8 - 2.0 |
| | CCA: 2% | Soaking/brushing Soak for 10 min. or brush for 3 coatings | Dry | 1.8 -2.0 |

*Table 11: Population of Coconut Crowing Countries in Asia Pacific and their Projected Requirements for Housing (in '000,000)*

| Country | Population | 1% of Population requiring housing unit | Cocowood requirement at 15 Cu.m. per housing unit | 5 % of population requiring housing unit | Cocowood requirement at 15 Cu.m. per housing unit |
|---|---|---|---|---|---|
| A.APCC member Countries | 1348.3586 | 13.4836 | 202.2538 | 67.4179 | 1011.2690 |
| Asia | 1342.7600 | 13.4276 | 201.4140 | 67.1380 | 1007.0700 |
| India | 914.0000 | 9.1400 | 137.1000 | 45.7000 | 685.5000 |
| Indonesia | 192.2200 | 1.9222 | 28.8330 | 9.6110 | 144.1650 |
| Malaysia | 19.6500 | 0.1965 | 2.9475 | 0.9825 | 14.7375 |
| Philippines | 67.0400 | 0.6704 | 10.0560 | 3.3520 | 50.2800 |
| Sri Lanka | 17.8600 | 0.1786 | 2.6790 | 0.8930 | 13.3950 |
| Thailand | 59.4000 | 0.5940 | 8.9100 | 2.9700 | 44.5500 |
| Vietnam | 72.5900 | 0.7259 | 10.8885 | 3.6295 | 54.4425 |
| Pacific | **5.5986** | **0.0560** | **0.8398** | **0.2799** | **4.1990** |
| F.S. Micronesia | 0.1040 | 0.0010 | 0.0156 | 0.0052 | 0.0780 |
| Fiji | 0.7780 | 0.0078 | 0.1167 | 0.0389 | 0.5835 |
| Papua New Guinea | 4.0000 | 0.0400 | 0.6000 | 0.2000 | 3.0000 |
| Solomon Islands | 0.3680 | 0.0037 | 0.0552 | 0.0184 | 0.2760 |
| Vanuatu | 0.1641 | 0.0016 | 0.0246 | 0.0082 | 0.1231 |
| Western Samoa | 0.1680 | 0.0017 | 0.0252 | 0.0084 | 0.1260 |
| Palau | 0.0165 | 0.0002 | 0.0025 | 0.0008 | 0.0124 |
| B. Other Countries | 161.9154 | 1.6192 | 24.2873 | 8.0958 | 121.4366 |
| Asia | **161.6200** | **1.6162** | **24.2430** | **8.0810** | **121.2150** |
| Bangladesh | 117.7000 | 1.1770 | 17.6550 | 5.8850 | 88.2750 |
| Myanmar | 43.9200 | 0.4392 | 6.5880 | 2.1960 | 32.9400 |
| Others | | | | | |
| **Pacific** | **0.2954** | **0.0030** | **0.0443** | **0.0148** | **0.2216** |
| French Polynesia | 0.2170 | 0.0022 | 0.0326 | 0.0109 | 0.1628 |
| Kiribati | 0.0784 | 0.0008 | 0.0118 | 0.0039 | 0.0588 |
| Others | | | | | |
| | | _ | | | |
| Total | **1510.2740** | **15.1027** | **226.5411** | **75.5137** | **1132.7055** |

** Source: Asia -Pacific in Figures, 1995, ESCAP*

# ANNEX 1 - PALM CHARACTERISTICS RELEVANT TO UTILIZATION

## *Structure/Anatomy*

The coconut palm is a monocotyledon; it has an erect pole-like stem and symmetrical crown; the trunk is 30-40 cm in diameter sometimes reaching a meter at the base. Once formed, it does not increase in diameter due to the absence of a cambium. The slender and branchless trunk reaches a height of 20-25 meters or more. Tall coconut varieties take 3-4 years to develop a stem above the ground. It bears leaf scars showing the insertion of the fallen leaves. The distance between leafscars indicates the rate of growth. Leafscars are closely spaced at the top and at the bottom of the trunk but distantly spaced at the middle portion.

In cross-section, the coconut stem has three distinct zones, namely the dermal, sub-dermal and the central zones with the dermal as the most peripheral portion just below the cortex, the sub-dermal between the dermal and the central zone or core. Its main anatomical elements include the fibrovascular bundles, fibrous bundles and the ground tissue.

The fibrovascular bundles consist of phloem, xylem, axial parenchyma and thick-walled schlyrenchyma fibres. The latter element serves as the palm's major mechanical support. The cell walls of the schlyrenchima fibres become progressively thicker from the centre to the cortex of the stem. The xylem is enveloped by parenchyma cells usually containing two wide vessels, a combination of wide and small vessels or clusters of several small and wide vessels.

The ground tissue is parenchymatous and its cell wall thickness decreases from cortex to the inner zone of the central cylinder.

## *Physical Properties*

The physical properties of cocowood depend largely on its density, moisture content and shrinkage *(Table 3*).

The oven-dry weight-green volume or basic density of cocowood decreases with increasing height of the stem and, at any given height, increases from the core to the cortex. In addition, the basic density at any particular height increases with the age of the palm. Overall, the basic density ranges from 100kg/$m^3$ at the top core portion to 900 kg/$m^3$ at bottom dermal portion of old coconut palms.

The moisture content is negatively correlated with the basic density, i.e. moisture content decreases with increasing basic density and vice versa. The amount of moisture in coconut stem increases with increasing stem height and decreases from the core to the cortex. The moisture content ranges from 50% at the bottom dermal portion to 400% at the top core portion of the stem.

The dimensional stability of the wood is determined by its shrinkage or swelling which accompanies a decrease or increase in moisture content below fibre saturation point.

Shrinkage and swelling cause drying defects such as checks and split. Unlike conventional wood where tangential shrinkage is almost twice the radial shrinkage, the tangential and radial shrinkage of cocowood are not significantly different.

### *Mechanical Properties*

The mechanical properties of coconut which define its end use are positively correlated with the basic density. As a result, cocowood has been classified according to three basic density groups as follows: High density wood (dermal) 600 kg/m$^3$ and above, medium density wood (sub-dermal) 400 kg/m$^3$ to 599 kg/m$^3$, and low density wood (core), below 400 kg/m$^3$.

*Table 4* presents the mechanical and related properties of the three density groups of cocowood based on green and dry samples. All values of the strength properties decrease with decreasing basic density. Except for impact bending, the values of the other mechanical properties of cocowood at 12% moisture content are significantly higher than in green condition.

The strength properties of high density cocowood compare favourably with *Dipterocarpus grandiflorus, Pentacme concorta*, and *Shorea polysperma* (*Table 5*) which are commonly used as structural materials for building construction. High density cocowood almost exhibits superior strength properties over the aforementioned conventional wood except modulus of elasticity which shows lower strength values as far as compression parallel to grain is concerned.

The medium density cocowood is comparable to *Pentacme concorta* in terms of modulus of rupture, stress at proportional limit and maximum crushing strength but it is slightly inferior in the rest of the properties. In contrast, the low density cocowood cannot compare with these wood species hence, it should be used only for non-load bearing structures.

### *Chemical Properties*

Coconut wood is comparable to Philippine hardwood/softwood and bamboo as far as holocellulose, lignin and pentosan content are concerned. However, it contains higher ash than Philippine woods. The proximate chemical composition of coconut wood are the following: hollocellulose (66.7%); lignin (25.1%) and pentosans (22.9%).

## ANNEX 2: COCONUT WOOD UTILIZATION TECHNOLOGIES

Efficient processing and utilization of coconut trunks are aimed at solving technical and socio-economic problems especially when the coconut farmer decides to replant his senile palms. Being a monocotyledonous plant, its anatomical, physical, chemical and mechanical properties are different from the conventional woods. Hence, processing techniques and equipment including appropriate machinery have been developed, modified and improved to process cocowood more efficiently and produce comparatively good quality products.

### *Logging*

The technology required for harvesting or logging coconut stems is almost the same as in traditional forest trees. However, the conveniently straight and branchless stems, and their nearly uniform volume and dimension allow the use of comparatively light and simple tools and transportation equipment. Logging operation in a coconut plantation is therefore easier and cheaper than logging under forestry conditions especially in mountains with steep terrain.

### *Sawmilling*

In sawing coconut logs, the most important factors in selecting the milling equipment are profitability and ability to be relocated if this is required; simplicity of design to avoid breakdowns which are difficult to repair in isolated situations; ease of operation as skills of operators will often be limited; an inexpensiveness as the industry is often situated in poorer and underdeveloped areas.

Different type of mills have been tested at the Zamboanga Research Centre in the Philippines and the Timber Industry Training Centre in New Zealand and information gathered could provide a guide to the selection of mills for different conditions. These mills include the medium-size portable sawmill, a larger transportable sawmill, light/general purpose portable sawmill, a mini mill, a breast bench with light weight carriages and a chainsaw with guide attachments.

Problems of sawing coconut logs are similar to the ones encountered by sawmillers when using high density species of tropical hardwoods.

### *Grading*

It has been established that no importer is prepared to make a commitment to purchase large volumes of coconut wood unless both quality of material and reliability of supply are guaranteed. Uniform grading standards for coconut wood are therefore highly desirable. A system of grading coconut wood and the mechanics of its implementation and control should be established in the producing countries. The mechanism for quality control should not restrict efficient management but should aim to protect and foster the interests of the country, the coconut wood industry, and its customers.

Quality control of coconut wood starts during the logging operation. Coconut wood should be graded hard, intermediate or soft, corresponding to high, medium and low density: high density is above 600 $kg/m^3$; medium density between 400 and 600 $kg/m^3$; and low density less than 400 $kg/m^3$. Because of the widely varying density of material within each log, and the difficulty of differentiating these by superficial inspection after sawing, it is essential that a grading, sorting and identification system be established to track the wood from different parts of a log and from different logs along the length of a tree; this should start in the plantation at the time of felling. Systems of this sort have been designed and are implementable.

### *Machining*

Another important phase in cocowood utilization is machining or the process of cutting and milling the cocowood into various shapes and patterns with the use of woodworking machines.

### *Seasoning and Drying*

Coconut wood must also undergo seasoning process to minimize if not completely avoid problems in its utilization: the appropriate moisture content levels of coconut wood for various uses are as follows: furniture - 10 to 12%; flooring - 11 to 17%; framing timber - 15 to 18%; joinery - 12 to 16%; and weatherboards - 15 to 18%. The common drying methods include air drying wood under shed, forced-air, and kiln drying. Depending on existing conditions, 25mm and 50mm coconut boards take 4 to 11 weeks and 16 to 21 weeks to air dry, respectively to attain equilibrium moisture content of 17% to 19%. Drying schedules have been worked out (*Tables 8 and 9*) for kiln drying coconut wood to avoid drying defects such as collapse, twist, wrap and check.

### *Preservative Treatment*

Coconut is not naturally durable when used in situations favourable to attack by decay fungi and wood boring insects particularly in ground contact and exposed to the weather. The low natural durability can be overcome by the application of suitable wood preservative treatment, for which appropriate prescriptions and dose rates have been developed. Choice of treatment depends on hazard level and cost which can be borne.

The recommended treating processes are presented in *Table 10.* The treatment schedules of the different processes have been established for coconut wood through a series of laboratory experiments, field and service tests of treated materials.

### *Finishing*

Good quality finish for cocowood involves sanding the surface to remove the knife marks and produce a smooth surface. The use of mechanical sanders instead of manual sanding facilitates finishing the surface of the wood.

Coating involves the sequence application of stain, filler, sealer and top coating materials such as lacquer, polyurethane, polyester and oil finish to enhance the natural beauty of the grain, colour and figure of cocowood products. Usually two or more coats of finishes are applied to cocowood to improve the appearance and quality of the wood products.

# ANNEX 3 - TECHNOLOGY PACKAGE CHAINSAW-TABLE SAW COCOLUMBER MANUFACTURING SYSTEM AND PRESERVATIVE TREATMENT BY SOAKING METHOD

## *Technology Description*

Lumber production from coconut trunk has been commercialized in the Philippines since early 1970's. Cocolumber is used for low-cost construction, furniture/handicraft, pallets, etc.

FPRDI studies show that coconut logs can be processed into lumber with different sawmilling equipment. One of the most efficient processing technique is the chainsaw-table saw lumbering system.

Round coconut trunks are sawn into halves or smaller dimensions as in flitches using a 10HP chainsaw at the cutting site. The flitches are transported to the lumber yard for resawing into desired dimension using a table saw.

The table saw may be stationary or mobile-type with 20 HP diesel engine. The sawblade is circular and the diameter is 510 millimetres.

The chainsaw-table saw lumbering system is designed for rural application. It involves relatively unskilled labour and the processing system may not be capital intensive. The lumber production per 8-hour operation is around 1,500 bd. R. The manufacturing cost is P5 38 per bd. ft. (Table A3.1).

Coconut lumber has a service life ranging from 4 (soft portion) to 18 months (hard portion) when used in contact with the ground. Coconut wood is susceptible to decay-causing organisms such as fungus, termites and powder-post beetles.

Treatment of cocolumber by **soaking for** 3-6 days in 6% copper-chrome-arsenate (CCA) preservative provides adequate protection from fungal and insect attack. This treatment could extend the service life of coconut lumber by ten times, thus, reducing maintenance cost for the end-users.

The cost of chemical and labour in the preservative treatment of cocolumber is P2.00 per bd. ft.

## *Outstanding Features Of The Technology*

- Chainsaw-table saw lumbering system requires lower investment cost and relatively unskilled labour compared to traditional sawmilling system.
- The system entails higher lumber yield/quality and lower processing cost compared to pure chain-sawing operation, the table saw provides an efficient system for resawing the flitches into smaller lumber sizes.

- Preservative treatment improves the durability and prolongs the service life of the cocolumber.
- Production and utilization of cocolumber broadens the raw material base of the wood industry and reduces the pressure on the exploitation of timber from the forest.
- Cocolumber is 3 to 4 items cheaper than traditional lumber.

### *Target Beneficiaries*

Entrepreneurs, cocolumber processors/traders.

### *Status Of Technology*

Commercialized since 1988.

### *Users Of The Technology*

The chainsaw-table saw lumbering system was piloted in Southern Leyte in 1988. Lumber produced were used for school building construction. A similar test was conducted in San Pablo City in collaboration with Mr. Roman de Castro, a chainsaw processor/producer of cocolumber.

The coconut log sawmilling technology was adopted in 1989 by the Quezon Cocolumber Co. in Lucena City; Daraga Agri-business Venture, Inc., Daraga, Albay, Rances Construction Enterprise" Bagacay, Tinambac, Camarines Sur; and the MCB Construction and General Services in Sta. Rosa, Laguna. The technology was also delivered in 1990 to the Guinan Development Foundation, Inc. (GDFI), Guinan, Western Samar and Leyte-Samar Rural Workers Association, Inc. (LABRADOR), Marasbaras, Tacloban City. However, these organizations were unable to commercially apply the technology for reasons beyond the control of FPRDI.

To date, the sawmilling technology is being utilized by some hardware business entrepreneurs in Los Banos, Bay, Sta. Rosa, San Pablo City and Lucena City in Laguna province. The cocolumber processors in these areas usually buy coco-flitches for resawing to required sizes in a stationary and electric powered table saw.

The cocolumber preservative treatment technology was adopted in 1988 by the Maquiling Cocolumber and Trading in Los Banos, Laguna. The MCT has its own treating facility which was constructed with the technical assistance of FPRDI.

## *Technical Features*

*A Cocolumber Manufacture*

| | | |
|---|---|---|
| 1. | Chainsaw description | |
| | Horsepower | I OHP |
| | Number of Teeth | S2 teeth |
| | Chain blade | ripping type |
| | Accessories | filing tools |
| 2. | Table saw description | |
| | Type of engine | diesel |
| | Basic horsepower | 20 Hp |
| | Transmission power | v-belts |
| | Sawblade diameter | 510 mm |
| | Sawblade thickness | 3 mm |
| | Kerf width | 4.4 mm |
| | Teeth type | carbide-tipped |
| | Number of teeth | 22-26 |
| | Peripheral speed | 940 rpm |
| 3. | Daily production capacity | 1,500 bd.ft. |
| 4. | Daily raw material requirement | 15 trees |
| 5. | Number of working days per month | 24 days |

*B. Cocolumber Preservative Treatment*

| | | |
|---|---|---|
| 1. | Treating tank description | |
| | Loading capacity | 4,500 bd. fl. |
| | Size | 1.2m x 1.2m x 7.62m |
| | Type of construction | concrete |
| 2. | Method of treatment | Soaking |
| 3. | Soaking duration | 3 to 6 days |
| 4. | Type of Chemical | Copper-chrome-Arsenate (CCA) |
| 5. | Chemical Concentration | 6% |
| 6. | Chemical Retention | 4 to 8 kg/cu.m. |
| 7. | Volume of lumber treatable per drum of CCA (125 kg) | 8,753 bd. d. |
| 8. | Volume of lumber treated per week | 4,500 bd. ft. |

### *Financial Analysis*

| | |
|---|---|
| Fixed Investment | |
| One (1) Chainsaw | 45,000 |
| One (1) table saw assembly (portable) | 110,000 |
| One (1) shed (200 sq. m. floor area) | 100,000 |
| Office equipment and furniture | 10,000 |
| Land (1,000 sq. m. at P400/sq. m.) | 400,000 |
| Treating trough | 10.814 |
| | --------------- |
| | P675,814 |
| Working Capital (2 mos.) | |
| Chemicals (CCA) | 60,000 |
| Raw materials | 216,000 |
| Direct Labour | - 84,720 |
| Fuel and lubricants | 16,800 |
| Hauling | 57,600 |
| Repair and maintenance | 11,940 |
| | -------------- |
| | P 447,060 |
| **Total Investment Cost (Pesos)** | **1,122,874** |

*Gross Sales per year* *P 3, 888, 000*

| | |
|---|---|
| 216,000 bd.ft. x P7.50/bd.ft. = | Pl,620,000 |
| 216,000 bd.ft (treated) x P10 50/bd.ft. = | 2,268,000 |
| | -------------------- |
| | P3,888,000 |

| | | |
|---|---|---|
| *Net Income (ave. per year)* | *Year 1-5* | *P 316,877* |
| | *Year 6-10* | *P 401, 766* |

| | |
|---|---|
| NPV | + 225,371 |
| ITRR | 26% |
| ROI | 32% |
| CPP | 1.65 yr |

***Table A3.1 - Cocolumber Manufacturing And Treatment Cost***

| items | Total Cost | Unit Cost |
|---|---|---|
| | (P/mo) | (P/bd.ft.) |
| A. LUMBER MANUFACTURE | | |
| **1. Raw Materials** | | |
| 15 trunks/day x P300/trunk x 24 days | 108,000 | 3 00 |
| **2. Direct Labour Cost** | | |
| Felling/bucking and Flitching (contractual) | | |
| 15 trunks/day x P75/trunk x 24 days | 27,000 | 0 75 |
| Table sawing (P420/day x 24 days) | 10,080 | 0 28 |
| 1 operator x P150/day = 150 | | |
| 1 receiver x P90/day = 90 | | |
| 2 helper x P90/day = 180 | | |
| 420 | | |
| **3. Fuel and lubricants (P350/day x 24 days)** | 8,400 | 0.23 |
| 8 li gasoline/day x P9.12/li = 73 | | |
| 3 1i oil/day x P45/li = 135 | | |
| 20 li diesel/day x P7.12/li = 142 | | |
| 350 | | |
| **4. Hauling of flitches/lumber** | | |
| 3000 bd.ft/day x PO. 40/bd.ft x 24 days | 28,800 | 0.80 |
| **5. Repair/Maintenance** | 5,970 | 0 17 |
| 4 chainsaw blade/mo @P950 = | 3,800 | |
| 4 round files/mo @ P'90 = 360 | | |
| 4 flat files/mo @ P190 = 760 | | |
| Retipping of circular saw = 650 | | |
| Grinding of circular saw = 400 | | |
| 5970 | | |
| **6. Depreciation (P223/day ~ 24 days)** | 5,352 | 0.15 |
| Chainsaw P45,000/300 days = 150 | | |
| Table saw P110,000/1500 days = 73 | | |
| 223 | | |
| **Sub-Total** | **193,602** | **5.38** |
| B. LUMBER TREATMENT | | |
| **1. Chemical** | | |
| 2 drums CCA at P15,000/drum | 30,000 | 1.71 |
| **2. Labour** | | |
| 4 persons. x P110/day x 12 days/mo. | 5,280 | 0.29 |
| **3. Depreciation of treating trough** | | |
| P10,814/480 mos. | 23 | 0 001 |
| **GRAND TOTAL** | **228,905** | **7.38** |
| | | |

*Assuming 50% of the total monthly production will be treated

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