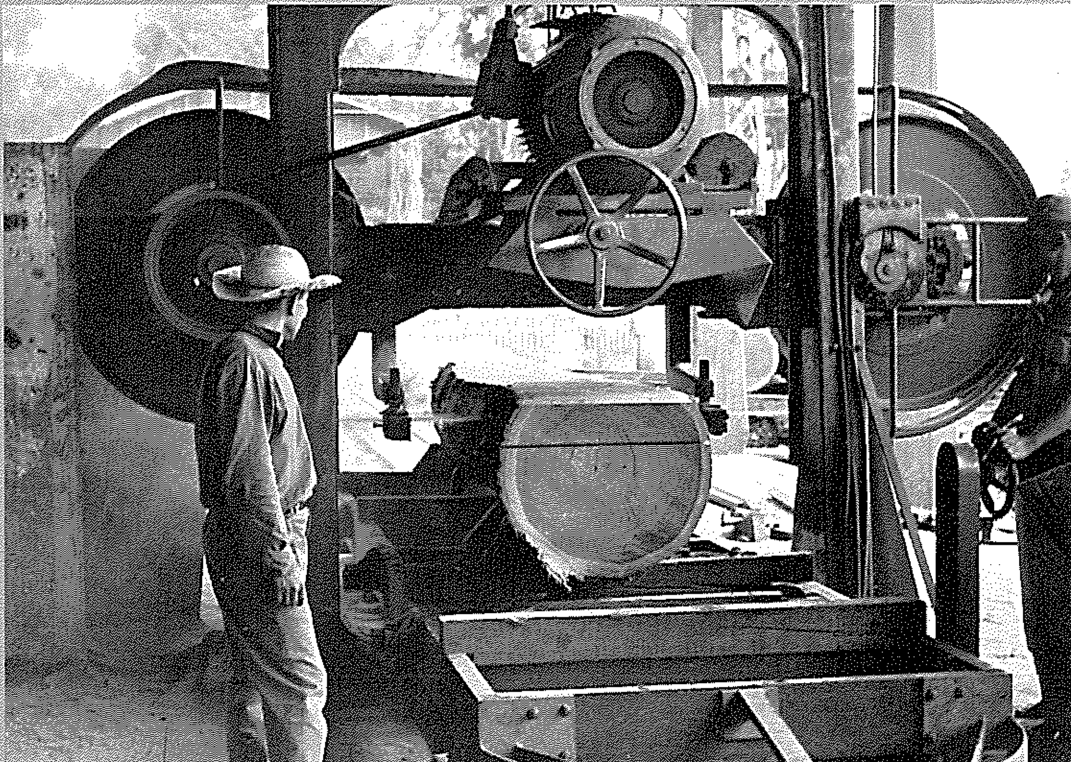
FAO FORESTRY PAPER 28

small and medium sawmills in developing countries



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS ROME

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small and medium sawmills in developing countries

a guide for their planning and establishment

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome 1981

M-36
ISBN 92-5-101155-9

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INTRODUCTION

In developing countries the Forest Industries are often a key link in improving the economic and social life of rural communities. However, often the more integrated wood-using industries require a large uncommitted forest resource and need extensive market development, skilled labour and significant capital. As a way of leading to larger industry, the development of a small sawmilling operation is often an excellent first step. This is because of:

- The comparatively low investment cost per unit of production.
- The simplicity of operation and the ability to start in a fairly labour-intensive way.
- The flexibility of production volume and of replacement of labour with capital at a later date.

In addition, the benefits of sawn wood production to a country in terms of local supply, import substitution, the multiplier effect on rural employment, and possible export earnings, can be significant.

The factors to be considered when determining the viability of a sawmilling venture location, markets, recovery, skilled labour, machinery, capital - are many and are often interdependent. FAO felt that a simple guidebook would be of assistance to companies and governments in developing the possibilities for small to medium sawmill industries.

Because of big differences in techniques and processing which apply, it is not possible in one publication to cover all types of small to medium sawmills dealing with both soft woods and hardwoods. This guide sets out to be simple and suitable for use by people without technical qualifications. It deals with mills from 5,000 to 20,000 cubic metres log intake per year and generally in the following areas where there is most need for assistance:

- Tropical hardwood areas without a high proportion of valuable export species.
- Producing construction sized sawnwood or simply graded boards for furniture or other uses, mostly air dried.
- Selling primarily to local or regional markets.

The guide is divided into two parts:

Part I. Basic Considerations. This section discusses the factors to be taken into account when considering a sawmilling venture and how that information should be collected and used to arrive at an investment assessment. It discusses the facets of marketing, log supply, production, personnel, engineering and construction, costing and accounting.

Part II. Case Studies. Three specific examples are taken and the methodology described in Part I is detailed for each case. The examples chosen are:

- A small portable mill in East Central India, cutting 5,000 m^3 hardwood log/year from moist tropical forest. This is the sort of mill which might accompany forest clearing associated with a road or rail development project.
- A 10,000 m^3 log intake mill based in Indonesia/Malaya.
- A permanent 20,000 m^3 mill based upon tropical hardwoods in Central America.

Throughout the guide emphasis has been placed upon sawmill design and operation simplicity. This keeps capital requirements to a minimum and increases the job creation opportunities. No electronic devices have been included and manual operations are favoured, except in those circumstances where mechanical assistance is necessary for safety and welfare reasons.

The manual is based upon work by the Sandwell Group of Vancouver. The figures quoted are not intended as specific to a given country and are not definitive. They are based upon 1979 values and are estimates only intended to illustrate the procedures to be used.

PART I - BASIC CONSIDERATIONS

1.0 RAW MATERIALS

Throughout this guide it has been assumed that the raw material to be used comprises tropical hardwoods. This covers a wide range of possible wood qualities from hard refractory woods to those which are easily sawn and from relatively small diameter logs of the dry deciduous forest to large diameter logs of the type common in moist tropical high forest.

1.1 Source of Supply

Before planning begins the areas of forest which will be the source of raw material must be clearly defined on an official map.

The following points should be examined:

i. Does the area appear to have an adequate supply of wood in general terms?

ii. Has the area been logged before?

iii. Are there existing rights over the area such as cultivation, hunting, or gathering of minor forest products?

iv. What means of access are there? Will access be hampered by, say, permanent agriculture in the valleys?

v. How many kilometres of access road will have to be constructed?

vi. If public roads are to be used,

- what are the road limits?
- what is the standard of maintenance? are they passable all year round?
- is the user expected to contribute to road maintenance? if so, how much?

If the answers to the above questions are acceptable, written authority to cut in the area must be obtained stating:

i. Period for which licence to cut is granted, whether the licence is renewable and whether the rights are exclusive.

ii. Species which may be cut.

iii. Minimum diameter (dbh) which may be cut.

iv. Volume which may be cut per annum.

v. Road construction specifications.

vi. Other responsibilities of user.

vii. Allowable defect.

viii. Scaling regulations.

ix. Stumpage or royalty to be charged.

x. Responsibility of licensee for regeneration, erosion control, etc.

The clarification of these points is an essential first step before planning begins. Unfavourable conditions in any one of these aspects could affect the feasibility of the proposed plant and they must be carefully examined from this point of view.

The next important step is to establish the actual volume of raw material available. Normally some form of inventory information exists. THIS SHOULD BE CHECKED by a reconnaissance type cruise (0.01% intensity is sufficient). The facts which should be checked are: standing volume of utilizable species, uniformity of distribution, percentage of defect and recoverable underbark volume of usable logs which can be delivered to the mill. The last point is the most important and is rarely calculated in forest service inventories. The net recoverable merchantable volume varies from as low as 20% to over 50% of standing volume, depending on tree size, species, degree of defect, amount of breakage and loss during extraction and the intensity of utilization. It is usually higher in mixed Dipterocarp forests and lower in dry deciduous woodland.

It is very difficult to set minimum volumes for the economic extraction of a raw material supply. If the average recoverable underbark volume of usable species is less than 15 m^3/ha and if these species do not have a net mill value of at least US $150/$m^3$ rough sawn, extraction at an acceptable cost will be difficult to achieve. Exceptions are unusually low extraction costs due to favourable terrain, low labour costs or short transport distances.

1.2 Species to be Used

Tropical hardwood forests contain many different species and technologists have stated that much of this wood is theoretically usable. People, however, have strong prejudices against woods that they have not used before. Although new species may be promoted and sold by accurate sawing, good presentation and low price, it is unwise to consider them as the only basis of production in a new mill unless their properties are outstandingly good or there is a clear demand for these species. In planning a new enterprise it would be wise to assume that 70 to 90% of the production for the first five years would be based upon species which are and have been generally accepted for construction purposes. The balance can be of a few lesser known species, the proportion of which may be increased as a wider experience of market acceptance is obtained.

The best way to establish species acceptability is to talk with users such as sawmillers, building contractors, furniture makers and carpenters. Small farmers or forest villagers are often very knowledgeable on uses of lesser known species. Samples of acceptable wood should be collected from sawmills and checked against those in the area to be cut, since there is often confusion in local names. If possible, local forest department officials should be asked to verify species and to assist in preparing a list of standard local names to be used.

1.3 Cost of Delivered Raw Material

The cost of logs delivered to the sawmill is usually the highest single cost involved in producing sawn wood. Depending upon the difficulty of logging, this may amount to 60% of manufacturing costs. It is, therefore, important that an accurate estimate is obtained for this cost.

Wood cost is a function of how much wood is removed per unit of area and the physical barriers to this removal. The smaller the volume of wood removed per unit area, the higher will be the proportion of these costs for each unit of volume. Such items as overheads, taxes, workers housing, machinery depreciation and timber exploration are fixed costs and do not change with the volume removed.

The estimation of delivered wood cost from basic data requires considerable experience. If at all possible, a person of experience should be used to collect this information. If this is not possible, a reasonable estimate can be made by talking to logging contractors in the area or, if not available, in other areas of similar forest type and terrain. Such estimates must be cross-checked using several sources.

Before attempting an estimate of delivered wood cost, the following points must be settled:

i. Approximate average volume to be removed per unit area, average log size and weight.

ii. Method of extraction to be used, e.g., animals or machinery.

iii. Type of access to be used, e.g., water vs. roads.

iv. Duration of logging season. In many moist tropical areas this is 6 to 8 months and often less.

v. Whether contractors are to be used or whether the mill will extract its own logs.

Having made these decisions, the cost of the following component operations should be estimated:

i. Exploration and location of stands to be developed.

ii. Felling.

iii. Skidding, including cost of skid trails.

iv. Bucking.

v. Scaling.

vi. Loading.

vii. Road construction and maintenance.

viii. Transportation to mill.

ix. Overheads (to include accounting, supervision, taxes, workshops, stumpage or royalty).

The following costs based on 1979 values refer to different situations and are given as an example of the order of magnitude to be expected in different types of operation. They should not be applied to any other situation.

These costs do not include royalty or stumpage payments, capital replacement or interest costs. Length of truck haul has a significant effect.

Central America	-	fully mechanized operation, crawler tractors and skidders, road construction, log transportation, eight month logging season.
	-	30 m^3/ha recoverable volume removed.
	-	delivered log cost (1978) US \$30-45/m^3.
South America Amazon	-	similar to above.
	-	delivered log cost (1975) US \$20-25/m^3.
Southeast Asia	-	swamp forest - river transport - US \$25-30/m^3. hill forest - road transport - US \$8 -18/m^3.
West Africa	-	moist tropical - fully mechanized - US \$12/m^3.
East Africa	-	plantations - mechanized - US \$6-12/m^3.

2.0 MARKETING

2.1 General

Marketing is one of the most important functions of any business venture and yet its importance is frequently underestimated. This is particularly evident in the case of small to medium-sized sawmills. Typically, those involved in the development of these ventures have work experiences associated with wood harvesting or milling and have had only limited experience with the marketing of sawnwood. As a result, the conceptual planning of new mills often focuses almost entirely upon the needs of the producer rather than the marketplace - and often with disastrous results.

Marketing embraces a wide range of activities. It involves the identification of market opportunities in terms of location, product specifications and potential sales volume and price. This information is of critical importance to the successful development of a sawmilling project and it is, therefore, very important that the relevant data be as comprehensive and reliable as possible.

In Europe and North America the development of market data and projections usually involves the application of relatively sophisticated techniques involving time series analysis of growth rate factors and wood consumption patterns. Projections of population growth, economic growth rates and factors affecting income can be used to forecast wood consumption. While a prospective developer of a small sawmill would probably not undertake such projections himself, he can obtain from industry associations and government agencies the results of detailed market research work which has been carried out by others.

Many developing countries with tropical hardwood forests have great difficulty in defining the correlation between, for example, population growth rates and sawnwood consumption. Many of these countries have a dual economy in which the population can be roughly categorized into two groups: the high income earner/consumer and the low income essentially non-consumer.

In assessing the local market careful attention must be given to its present and potential size. Forecasts of demand based on time series data obtained from import statistics can be misleading in that the level of imports is often governed by non-market constraints such as import restrictions used to conserve foreign exchange. Local prejudice against wood as a housing material or outmoded building regulations may also seriously limit the usefulness of the conventional approach to market forecasting.

In order to develop a realistic assessment of market opportunities and constraints for small to medium-sized local mills, a practical approach is called for. Reliable, published data will be difficult to obtain and often will not exist. Emphasis must be placed on the analysis of local end-use requirements and the identification of trends. Much reliance will have to be placed upon the judgement of those examining the market and therefore a sound knowledge of the local community is most desirable. Because of the subjective nature of the work, many of the estimates may be imprecise.

The most likely sources of information are:

i. Government agencies.

ii. State-owned corporations.

iii. Co-operatives.

iv. Private contractors, architects and engineers.

v. Existing sawmills.

vi. Local sawnwood agents, wholesalers and retailers.

vii. Private sector industrial users.

The following sections outline a simple approach to the preparation of a realistic market plan for small to medium-sized sawmills.

2.2 Market Areas

Before proceeding with the development of detailed market data, it is useful to define the approximate geographic market boundaries. This will require a combination of local knowledge and judgement and an assessment of the following factors:

i. Natural geographic boundaries, including waterways, mountain ranges and desert areas.

ii. The location, output and approximate market areas of existing sawmills.

iii. The location and size of significant centres of population.

iv. The location of potentially significant industrial consumers of sawnwood such as furniture manufacturers, mines, railways, pallet makers, export packers, truck and trailer manufacturers, etc.

v. Existing transportation services including routes, availability, costs per ton-mile, and reliability.

vi. Any national, regional or local government restrictions which may constrain the distribution of sawnwood.

vii. The use of imported sawnwood including volumes and some estimate of distribution patterns.

Based on the preceding information, a preliminary definition can be made of what appears to be a logical market area for the proposed sawmill. Subsequent research may cause this initial assessment to be modified somewhat: however, it will provide a reasonable basis for further study.

2.3 End-Use Categories

Having defined the market area, the principal uses of sawnwood within this region can be identified. These will include some, or all, of the following:

i. Residential housing - single and multiple family dwelling units.

ii. Institutional construction - schools, hospitals, clinics.

iii. Agriculture - animal shelters, storage sheds, fencing, feed troughs, crates.

iv. Public works - bridges, docks, irrigation systems, storage buildings.

v. Military - barracks, warehouses, pallets, carting.

vi. Railroads - ties, crossings, maintenance and storage buildings.

vii. Mines - mine timbers, workers housing, warehouses.

viii. Industrial construction - factory buildings, warehouses, workers housing.

ix. Manufacturing - furniture plants, prefabricated housing, truck and trailer manufacturers, pallets, crates.

x. Miscellaneous - general public consumption for renovations, additions, outbuildings, marine construction including fishing boats, barges and personnel carriers.

The identification of the various end-use categories within the market region, while a relatively straightforward activity, requires an intensive review of any published material (such as directories) and, most importantly, direct interviews with knowledgeable representatives of all applicable sawnwood consuming groups and of those engaged in the sawnwood manufacturing industry. These interviews should be organized in such a way as to obtain information required for the following stage.

2.4 Sawnwood Demand, Supply and Specifications

For each of the end-use categories identified in section 2.3, the following information should be developed: the specifications of sawnwood used, estimated annual consumption and supply, and future trends. Finally, the present and projected sawnwood supply-demand balance should be estimated.

i. Sawnwood specifications. It is vital to the planning of a sawmill, regardless of size, that a reliable definition be available of market requirements with respect to product specifications. To provide the necessary background information, the sawnwood specifications required by each of the end-use categories should be determined.

Attention to detail is most important at this stage, as seemingly insignificant aspects with respect to grade, size, etc., can be of critical concern to the design and operation of the sawmill. While it is unlikely that a single sawmill could meet the product requirements of all potential end-users within its market region, sound knowledge of the total picture can be of great value in making the final decisions as to which sectors to focus upon in a final market plan. Specific details which must be obtained are as follows:

quality	-	preferences with respect to species, colour, durability, strength, allowable defects.
size	-	thickness, width, length.
tolerances	-	allowable oversize and undersize tolerances.
dryness	-	acceptability of "green" sawnwood as opposed to requirements for partial drying or kiln drying.

ii. Annual consumption. For each of the end-use categories, estimates are required as to the present volumes sold. These estimates should, to the greatest extent possible, include the volumes of each of the main specifications within each end-use category. These volume estimates are essential to the development of an understanding of the market. Information in many instances will be most difficult to acquire. The researcher should not become too discouraged, however, as even a crude estimate, based on local knowledge and interviews, is better than a wild guess or, alternatively, no estimate at all.

iii. Existing sawnwood supply. An analysis should be made of the existing sawnwood supply within the market region. This should include the following possible sources of sawnwood:

- sawmills within the market region,
- sawmills within the country but outside the market region,
- imported sawnwood.

It should be reasonably easy to obtain information concerning the existing sawnwood supply within the region. As much detail as possible should be obtained, particularly with respect to species, dimension and quality. Data on sawnwood entering the market region from external sources (either domestic or foreign) may be more difficult to obtain as Government statistics are not always available or reliable. Also, detail as to specifications of imports may be lacking. Nevertheless, much useful information can usually be developed through interviews with those involved directly in the importation process, such as importers, wholesalers, retailers and transport organizations.

iv. Future trends. Some attempt must be made to identify any trends which might be expected to affect the existing sawnwood supply-demand balance, and hence the competitive position of a new sawmill. Demand can be affected by changes in population and national wealth, as measured by gross national product per capita. Of great significance can be any change in government policy that could bear upon the supply of new housing units. Similarly, other wood-using sectors of the economy within the market region may be developed as a result of government policy. Railways may be expanded, new industrial plants subsidized, major public works projects undertaken, etc.

Changes in sawnwood supply can occur due to a number of variables. Sawmilling capacity within the market region can increase or decrease due to factors such as wood supply, local market demand, the competitive position of individual mills, planned new mills, the availability of labour and so forth. Imports of sawnwood from mills outside the market region can change due to similar reasons, Imports from foreign suppliers may increase or decrease in the future as a consequence of protective tariffs, changing prices reflecting economic conditions external to the local market region and competition from domestic producers.

The following sources will provide useful information with respect to future trends and maximum use should be made of them:

- population forecasts,
- government plans,
- economic forecasts (public and private),
- judgement of experienced representatives of the sawnwood end-users and producers.

v. Supply-demand balance. Through examination of the previously developed estimates of current sawnwood supply and consumption, coupled with the review of probable future trends, it should be possible to develop a reasonable assessment of the likely supply-demand balance for sawnwood during the next five to ten years. Ideally, this assessment should deal with the main products. The forecast of the supply-demand balance will only be as reliable as the input data. While high levels of accuracy should not be expected, if the previous work has been done with care, a useful indication of future opportunities can be developed.

Also, projected shortages of certain types of sawnwood may be identified which can have a direct bearing on the planned product-mix for a new sawmill. Conversely, although it is unlikely, the supply-demand projection may reveal an excess of supply relative to demand, thus signalling the need for extreme caution in the short-term development of new milling capacity within the market region. Similarly, an excess supply of a particular item may be indicated, once again providing invaluable information in planning the product specifications of a new mill.

2.5 Distribution

It is important to determine the means by which the mill's product will reach the market-place. Local and regional distribution methods will have a great bearing on selecting an appropriate approach for a new mill. In situations in which there is an existing sawmilling industry within the market region, clearly developed distribution patterns may have been established, and it is probable that a new mill, particularly if it is small, would become part of the existing system.

In the absence of a well structured distribution network it will be necessary to determine the most effective means of distribution for any new operation. In any event, the existing situation should be carefully appraised. Distribution channels, and the associated costs, should be identified. This can usually be accomplished with little difficulty, particularly by someone who is familiar with local business practice. One or more of the following distribution systems will normally apply:

i. Direct Sales from Sawmill to End-User This usually involves local builders, etc., purchasing directly from mill inventory. The mill may deliver, either with its own vehicle, or by a contract hauler, to the user's designated site in exchange for a delivery fee. Alternatively, the user may pick up his requirements directly from the mill yard. This distribution method offers the advantage of simplicity and the avoidance of a "middleman". It is appropriate when volumes are low and there is no adequate distribution network in place. It does involve the mill operator in direct dealings with many customers and therefore a relatively high degree of paper work. Also, unless the terms of sale are strictly cash against delivery (or pick-up), the sawmiller exposes himself to considerable credit risk in that many of his customers may be of marginal financial means.

ii. Co-operatives. If the sawmill itself is part of a co-operative group, the distribution system may already be established. Alternatively, an independent miller may wish to distribute his sawnwood through one or more existing co-operative groups within his market region.

iii. Private Haulers. In some situations individual haulers may wish to buy sawnwood from the mill on speculation and then resell and deliver to local consumers, thus essentially performing the wholesale-retail function. Once again, credit risk is an important consideration and, in most cases, the sawmiller would be well-advised to deal only on the basis of cash upon pick-up.

iv. Retail Shops. If the market region includes one or more good sized towns, it is probable that sawnwood retail shops may exist. Although they will already have supply sources, it is likely that the output of a new mill will be of interest, particularly if there is an existing supply shortage. The sawmiller will need to decide whether or not to become contractually involved on an exclusive basis with any particular retailer, or whether to maintain an "open-market" position. Much will depend upon the reputation, size, capability and financial status of the various retailers available to the miller.

v. Wholesale Distributors. In major population centres in which large volumes of sawnwood are consumed and where there are many suppliers, the distribution channels tend to become more complex. As it becomes increasingly difficult for individual sawmills and retail operations to communicate effectively due to the number of firms and the wide variety of specifications involved, wholesale operators are formed to fill the need for further specialization. These "middleman" firms often prefer to have exclusive (or at least partially exclusive) arrangements with a group of sawmills in order to assure a supply source. If the wholesaler is well financed, the sawmiller's credit risk is minimized, and the mill's sales function is greatly simplified in that large volumes are sold at one time to one buyer (the wholesaler). While this may seem attractive, particularly to a mill owner/manager who is more interested in mill operations than marketing, there is a danger of becoming excessively committed to very few buyers (perhaps only one). Control over marketing can be lost, and the sawmill's management may become insensitive to changing trends in the end-use sectors of the sawnwood market.

vi. Government Agencies. National policy may dictate that all sawnwood production be distributed through one or more government agencies, in which case the question of selecting the most appropriate distribution channel obviously does not arise. However, in the absence of an overall national distribution system, there will undoubtedly be various governmental agencies whose activities include the utilization of sawnwood. Housing and transport authorities, civil works, transport agencies, government-owned industrial and resource companies and the military can all be large consumers of sawnwood. Typically, such agencies tend to deal directly with a sawmill and will arrange their own transport.

Usually a typical distribution system for a given sawmill will involve some combination of the foregoing elements. It is most important that a distribution policy be formulated during the planning stage in order to avoid conflicts and to assist in attaining the best possible price for the sawnwood. If, for example, it is decided to sell to local retail stores, a clear policy must be established and maintained with respect to dealings with private individuals or firms who might otherwise be customers of the retailer. Similarly, allocations of future production must be made and adhered to if agreements are made to support certain "middlemen" or supply specific government agencies.

2.6 Price

A sound understanding of the price structure for sawnwood within the market region is of great importance. Price is usually the most critical variable in determining the return on investment of a sawmill operation. In a competitive and uncontrolled environment the individual sawmill operator usually cannot exert much influence on price levels. It is particularly important that those who plan a sawmill development take an objective viewpoint of price and avoid any temptation to assume higher than actual levels or to make overly optimistic projections of future trends. A realistic assessment can only be achieved with a sound knowledge of local conditions.

The existing pricing mechanism for sawnwood within the market region should be carefully identified. Discussions should be held with sawmillers, wholesalers, retailers and government officials. Any special arrangements such as price ceilings and cartels should be taken into account. Care must be taken to identify all deductions which would normally apply. These can include all forms of taxes and special government levies, transport charges, handling costs, trade and cash discounts and commissions.

A comprehensive review must be made of the current price structure including separate prices for each species, grade and size. Care should be taken to identify the make-up of these prices in order that all appropriate adjustments can be made in working up equivalent prices at the mill (mill net price).

Finally, some attempt should be made to identify future price trends. To the extent possible, the major factors affecting sawnwood prices should be determined and assessed and past trends identified and analyzed in order to provide possible indicators of future movements. The projection of sawnwood prices should be approached with considerable caution, particularly when there is any competition from imported material within the market region. The developer planning a sawmill of the sizes considered in this manual should concentrate on attempting to identify the broad probability of significant price changes over the initial three to five year period of the mill's operation. If possible, the approximate timing and magnitude of such change should be estimated in order to plan for suitable contingencies in the project's working capital and cash flow projections.

2.7 Marketing Plan

Utilizing the information previously developed with respect to the characteristics of the available wood supply and the market, a simple marketing plan should be prepared. This is a vital aspect of the planning process and will lead to the most favourable utilization of the wood supply relative to market opportunities. The marketing plan should include the following elements:

i. Revised (as required) definition of the market area.

ii. Key end-use sectors of the market to which the mill's output will be directed.

iii. Sawnwood specifications (species, grade, size and seasoning) best suited to the wood supply and the market requirements of the selected end-use sectors.

iv. Distribution channels to be used.

v. The weighted average mill net price, based on current market levels and the appropriate product specifications.*

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* For a sample calculation, refer to illustrative case in Part II, Case Studies.

In addition to the preceding key elements of the marketing plan attention should also be given to the following:

i. Inventory levels required to meet day-to-day sales, particularly during periods of high seasonal demand.

ii. The need to develop grading rules in the absence of appropriate local standards. Since the product will be primarily of a construction type, with the emphasis on utility rather than appearance, a simple grading convention will usually be sufficient. Three to four categories should be adequate, with the defect allowances being related strictly to the suitability of the material for its intended end-use. Should it be necessary to develop grade definitions, it is advisable to follow a well proven model such as the Malaysian Grading Rules, with appropriate modifications for local conditions. Grading rules should be as simple as possible and free of ambiguity. They should be made easily available to all those in the production, marketing and usage of the mill's output. The main purpose of grading rules is to assure the buyer of the mill's products that the quality of a particular grade of sawnwood will be consistent at any time. Furthermore, price typically depends on the grade.

iii. The development of sales documentation and control procedures should be included in the planning process. Documentation should be kept as simple as possible. It should satisfy the control requirements of the firm's auditors and provide the necessary record-keeping for shipping, invoicing and inventory control.

iv. Although not usually necessary with a basic commodity such as construction type sawnwood, some consideration should be given to the possible need for advertising, particularly during the mill's start-up period. Usually a simple advertisement placed in the local newspaper or posted at community focal points will be sufficient, particularly if there is an existing under-supply of sawnwood within the market region.

3.0 INDUSTRIAL PROCESSING

3.1 General

The machinery required to manufacture the type of lumber contemplated in this guide is basically simple, the essential requirements being:

i. A machine to saw the log lengthwise along lines parallel to the surface of the log or to the axis of the log, so as to produce pieces of the desired surface.

ii. A machine to saw these pieces lengthwise to remove the wane (rounded edges) and produce narrower pieces of standardized width having parallel edges.

iii. A machine to crosscut the pieces so as to produce square ends of standardized lengths and trim off defective wood.

A variety of machines ranging from simple to elaborate are available to do this work. In keeping with the theme of this guide, only simple, reliable machinery which is easy to operate and maintain is considered. Such machinery, when properly maintained and operated, is quite capable of producing good lumber at a satisfactory rate, as long as log supply is suitable and adequate.

For the sizes of sawmills considered in this guide the machinery required would be:

i. A "headrig", consisting of a travelling carriage capable of transporting the majority of logs for longitudinal cutting and either a circular or band headsaw. The small number of logs which exceed the headrig capacity should be split in half lengthwise, usually by chainsaw.

ii. A "resaw" of circular or band type, to accept large slabs and cants from the headrig and make further longitudinal cuts through the width or thickness.

iii. An "edger" with at least two parallel saws capable of being set to standardized spacings by hand controls and making longitudinal cuts through the thickness of pieces received from the headrig or resaw.

iv. A "trimmer" consisting of one or more fixed or movable saws arranged to crosscut pieces arriving from the headrig, the resaw or the edger.

The auxiliary equipment needed includes the following:

i. A means of transporting "bucked" logs from the log storage area (land or water) to the infeed deck of the headrig.

ii. A log infeed deck to facilitate loading the logs onto the headrig carriage.

iii. A log turning device to turn the logs onto carriage for best sawing position.

iv. A rollcase or other means to receive the pieces sawn off the log by the headsaw and transport them to the resaw and edger.

v. Infeed tables to receive and hold pieces waiting to go through the resaw and edger.

vi. Outfeed rollcases to receive boards from the resaw and edger.

vii. Transfer arrangements and tables leading to trimming and cross-cutting.

viii. A green chain where freshly cut boards are graded for quality and sorted for size and length.

ix. Means to collect and remove from the immediate operating area all residues such as sawdust, bark, edgings, trim ends and broken pieces.

x. Facilities to segregate and store the above residues for use as fuel and pulp mill furnish or to be used by secondary industries, agricultural concerns, and so on.

3.1.1. Type of mill to be considered

The principal types of small sawmills to be considered in this guide are as follows:

- Mobile or portable sawmills,
- Semi-permanent sawmills,
- Permanent sawmills.

i. Mobile or portable sawmills usually consist of a circular saw headrig, a simple log carriage, a two-saw edger and a diesel or gasoline mechanical power unit.

   This machinery is usually mounted on a prefabricated steel framework equipped with road wheels so that it may be towed into the working area where it is blocked and levelled. Modern units of this type are available from a number of sources and cost from $80,000 to $200,000 depending on the options selected and based on 1979 prices.

ii. Semi-permanent sawmills are comprised of conventional units of headsaw, carriage, edger and trimsaws mounted on steel and timber support structures on timber foundations. Minimal weather protection is provided and the sawmill may be dismantled and moved to a new location every two or three years as the log supply dictates. The cost of a semi-permanent sawmill of this type driven by diesel power and with minimal auxiliaries will be from $800,000 to $1,600,000.

iii. Permanent sawmills are comprised of conventional units of headsaw, carriage, resaw, edger and trimsaw with rollcases, transfer tables and refuse conveyors, all mounted on steel and timber supports on concrete or treated timber foundations. Permanent types of building construction provide weather protection and the entire mill forms an important factor in the community in which it is located. The cost of this type of sawmill will be from $1,700,000 to $2,500,000.

The specific type of mill chosen will be influenced by the state of development of the log supply and whether or not a market for the mill output already exists.

Where the log supply is to be drawn from a previously unused forest area, there will usually be a considerable volume of logs extracted during the initial development phase as land is cleared for roads, landings and building sites. These logs can be conveniently processed into timbers and planks by using a mobile or portable mill close to the source of supply. The lumber produced can be utilized for forest and sawmill development or it can be sold to generate cash flow and assist in developing markets.

If the log supply is to be drawn from an area already producing a small quantity of logs for use in saw pits or low-powered private sawmills, then there would be a basis on which a semi-permanent or permanent sawmill could be developed.

3.1.2 Log Supply of up to 5,000 m^3/A

For a log supply volume of about 5,000 m^3 per annum a mobile or portable sawmill operation is the most economical approach and such a sawmill can follow the developing logging roads into previously unused areas. Capital requirements are low, the quality of lumber produced is quite acceptable for the end-uses contemplated, and operating manpower is four to eight men depending on options selected.

A typical layout of a small mobile or portable sawmill is shown in Figure 1 and Plate 1.

Plate 1 Mobile circular sawmill

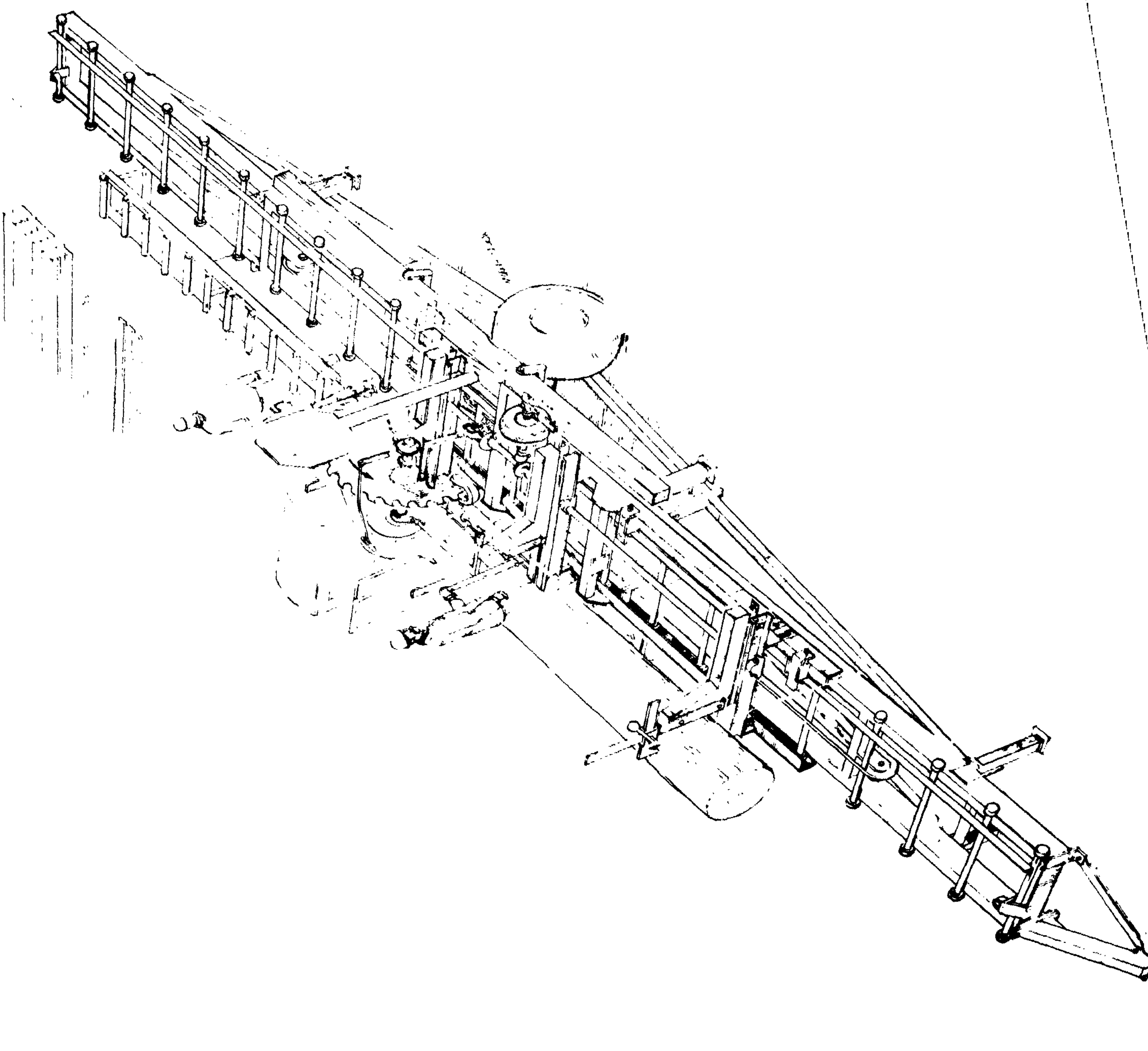
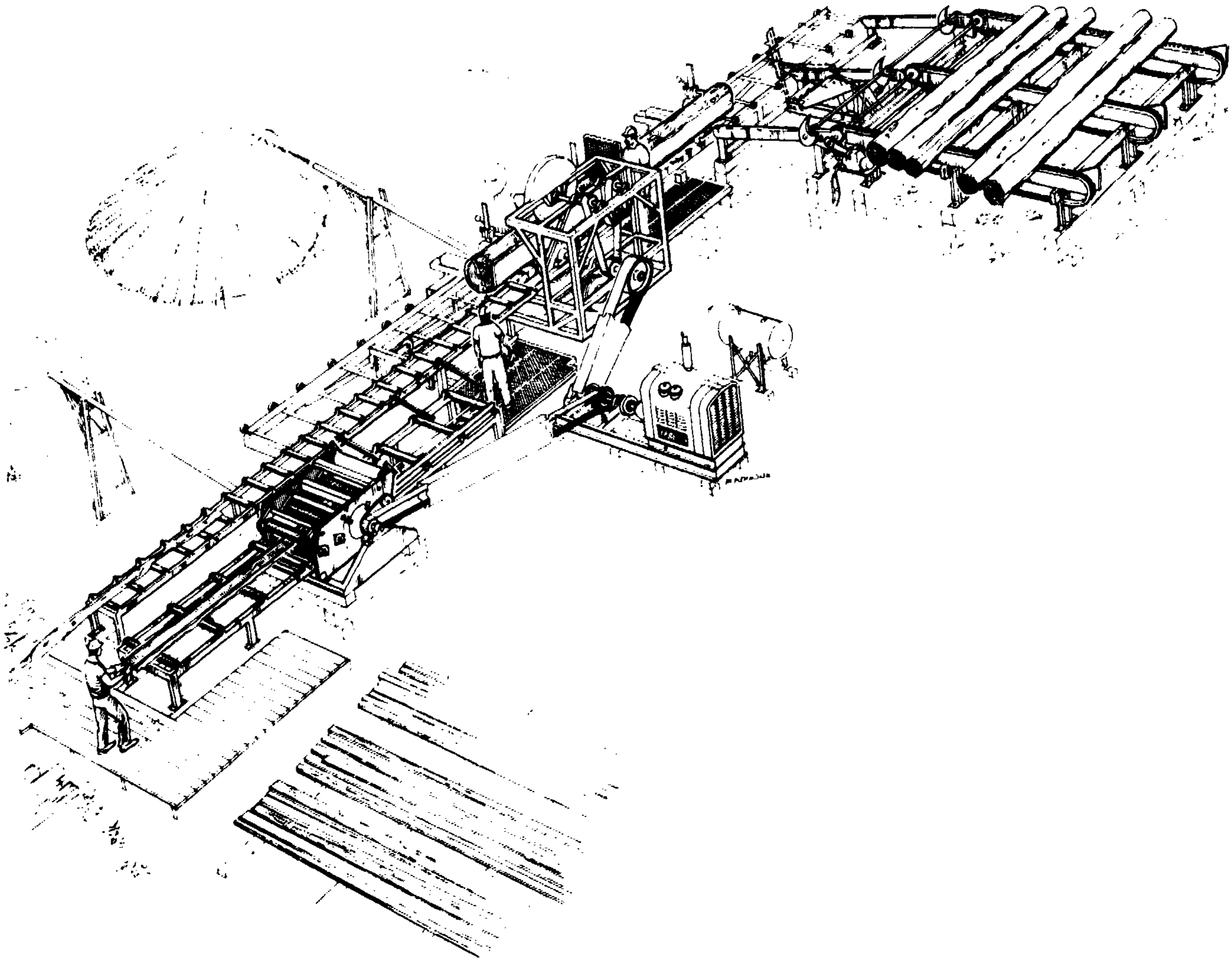


Plate 2 A semi-permanent circular sawmill set directly on the ground



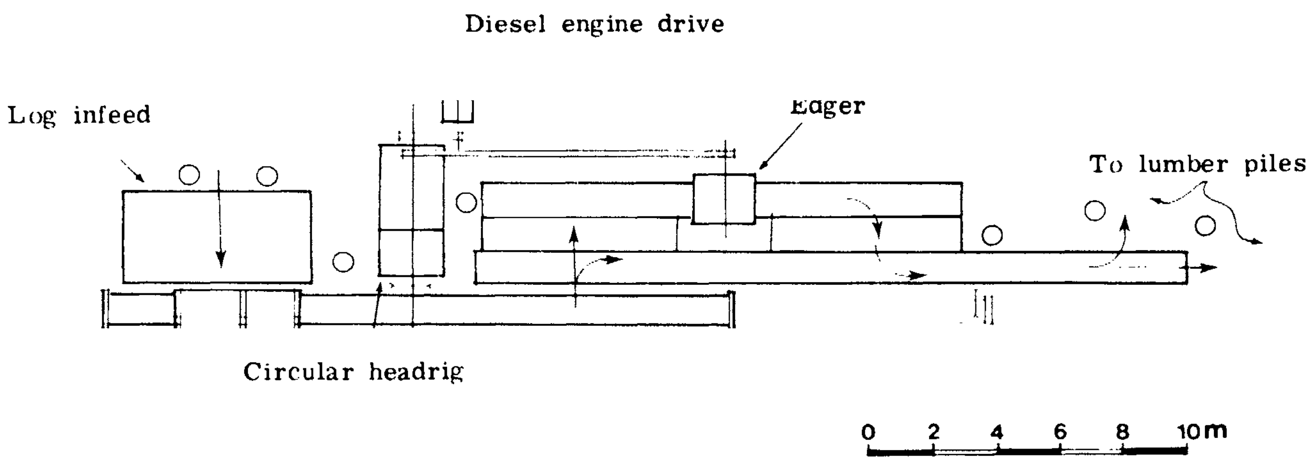


FIGURE 1 - LAYOUT FOR SMALL OR PORTABLE SAWMILL

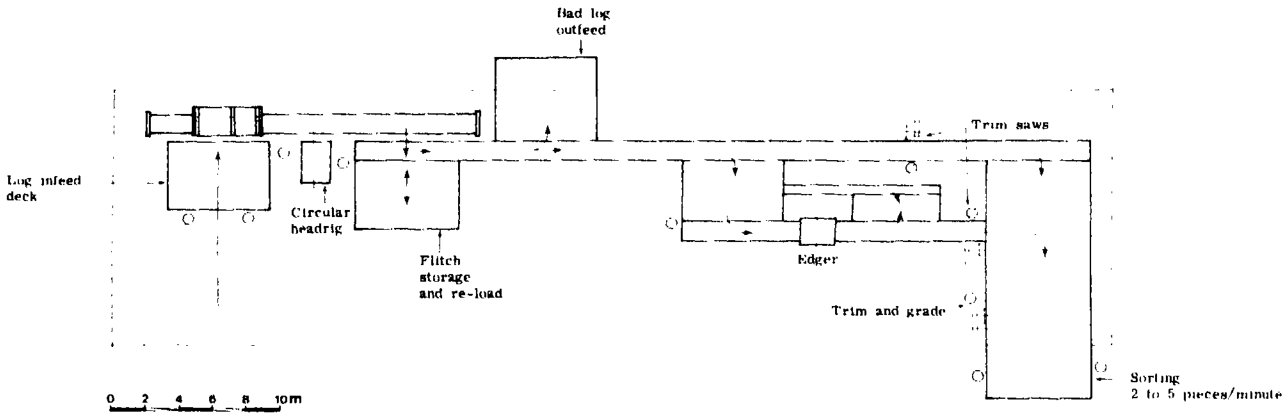


FIGURE 2 - LAYOUT FOR SEMI-PERMANENT OR PERMANENT SMALL SAWMILL

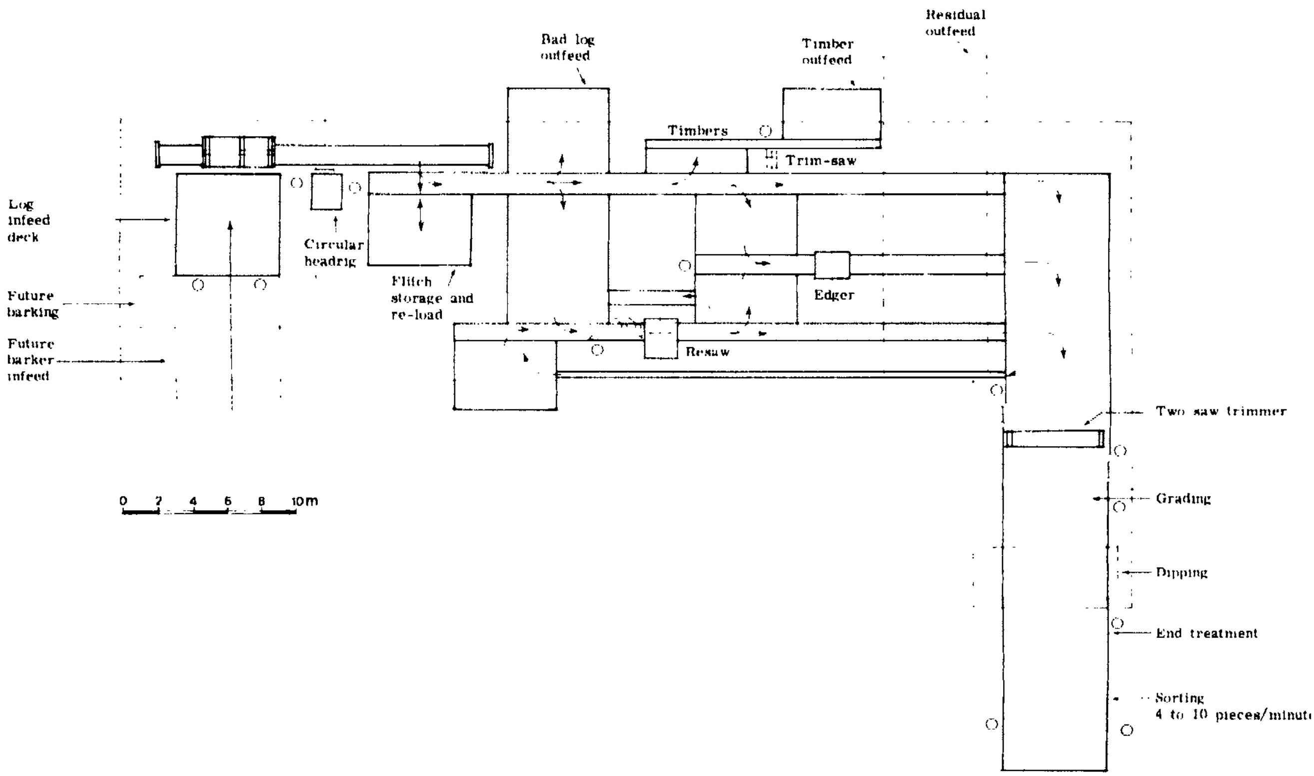


FIGURE 3 - LAYOUT FOR PERMANENT SMALL SAWMILL

3.1.3 Log Supply of up to 10,000 m^3/A

With a log supply volume of about 10,000 m^3/A a semi-permanent mill permits more flexibility in the range of end products, improves dimensional accuracy in sizing and increases lumber recovery from the logs. Auxiliary equipment such as rollcases and transfer tables can be included to facilitate lumber handling within the mill, as well as refuse and sawdust conveyors to assist in keeping the working areas clear.

Such a mill could be located near an established community where stability of the work force would be an asset, and the availability of by-products from the sawmill could encourage small secondary industries. The primary lumber output of the sawmill could be sold in the immediate area if a demand exists, or be transported to developed areas.

If an increase in the volume of sawlog supply over a period of years from 10,000 m^3/A to 20,000 m^3/A is feasible, then the initial mill could be constructed as a permanent mill, laid out in such a way that expansion to the higher capacity can be easily achieved whenever the demand for lumber justifies such expansion.

A typical layout of a semi-permanent or permanent sawmill is shown in Figure 2 and Plate 2.

3.1.4 Log Supply of up to 20,000 m^3/A

With a sustained log supply of about 20,000 m^3/A a permanent mill is feasible and may well become a major factor in the development of local communities.

With an input of this magnitude a resaw is added to share the load with the headrig and more trimming and sorting capacity is necessary. Furthermore, log handling into the mill, log cleaning, removal of finished products and of by-products must keep pace with the production capabilities of the mill machinery. Generally, more power is applied to the headsaw, resaw and edgers to obtain faster cutting speeds than those used in semi-permanent mills.

The layout of a permanent sawmill as shown in Figure 3 is an augmented version of the mill described earlier for 10,000 m^3/A.

3.2 Site Selection

Assuming that an adequate source of logs has been identified (Section 1.1), the selection of a site for a sawmill would be influenced by three major factors, namely, the type and scale of the sawmilling operation, the cost of transporting logs to a proposed site, and the location of an existing community that could provide much of the work force and reduce or possibly eliminate the need for building houses for employees and other services.

In opening up a new area not previously logged a mobile or portable sawmill following the road development can provide a source of construction material or can generate early cash flow with minimal capital investment. A suitable site in this case would be a small clearing on a level area at roadside.

In the case of larger projects with an established, reliable log extraction operation, a semi-permanent or permanent sawmill is more suitable. A mill of this type requires some form of log transportation system to deliver logs from the forest to the mill log yard. By locating a sawmill near an established community it may be possible to take advantage of existing roads or rivers for log transportation.

Since the costs of loading logs onto trucks or into a river and offloading to storage at a sawmill are independent of distance travelled, the benefits to be derived from a better site location such as near an existing community usually outweigh the costs of any extra distance of transportation.

3.2.1 Site Criteria

The following points will serve as a checklist for evaluating potential sawmill sites:

i. The terrain should be fairly level or gently sloping to facilitate drainage.

ii. The sub-soil should be compact, well-drained sandy gravel able to sustain wheel loads from logging trucks and fork-lift trucks.

iii. The area should not be subject to flooding by high water levels in nearby rivers or lakes or by flash floods from higher ground.

iv. It should be accessible to road or river or both to facilitate log transport from the forest to the mill and the shipment of lumber to the market areas.

v. If adequate electric power can be brought to the site from a nearby source, there is a major capital cost and operating cost advantage.

vi. There should be a good fresh water supply for drinking, log sprinkling and fire-fighting

vii. Location close to an established community provides the social amenities desirable for a stable work force and assists in the development of the community.

viii. Direction of prevailing winds should be such as to carry any smoke or dust away from the community.

3.2.2 Site Area

For a small mobile or portable sawmill operating close to the forest access roads, an area of one to two hectares is sufficient to accommodate minimal log storage, the sawmill, lumber storage and traffic circulation.

For sawmills processing 10,000 to 20,000 m^3/A of logs the site area may be estimated in the following manner:

3.2.2.1. Log Yard

i. Assume an average yard inventory of about 2,500 m^3 of logs (or whatever is necessary to carry over any expected logging shutdown period).

ii. Assume maximum log length to be 5 m.

iii. Assume stack height to average about 1.5 m.

iv. Assume average stack density to be about 50% (allows for short logs, bowed logs, etc.).

v. Allow for roadways with a width of 10 m between stacks and 10 m wide roads at the sides and ends.

Then, area occupied by stacked logs is

$$\frac{2{,}500\ m^3}{1.5\ m\ \text{height} \times 0.5\ \text{density}} = \pm 3{,}330\ m^2$$

Total area of log storage including roadways and circulation ranges between four and five times the stack area, depending on yard configuration. Therefore, for single species storage of 2,500 m^3 logs, allow 3,330 x 4.5, or approximately 15,000 m^2 for the yard area.

If a species separation is made in the log yard, then more area will be needed so that the inventory of each species may be built up without overlapping into the area assigned to another species. If the maximum inventory of each species is to be about 2,500 m^3, then the total yard area will be approximately 15,000 m^2 times the number of species groups. Hence, if 3 species group separations are made, the necessary log yard areas will be approximately 15,000 x 3 = 45,000 m^2.

It can be seen from the above that the log yard area is a function of log inventory requirements rather than of sawmill capacity, although the larger sawmill will carry the greater log inventory to accommodate periods of logging shutdown due to bad weather conditions, for example.

3.2.2.2 Air Drying Yard

i. Assume an average period of 6 weeks in the air drying yard for stacks of lumber.

ii. Assume about 60 m^3 solid wood equivalent (S.W.E.) of lumber from each 100 m^3 of logs processed by the sawmill.

iii. Assume that stacks contain about 20 m^3 (S.W.E.) of lumber(5m x 2m x 2m).

iv. Assume maximum stack length to be 5 m.

v. Assume average stack density to be about 80%.

vi. Allow for roadways with a width of 10 m between stacks and 10 m wide roads at the sides and ends.

Then, lumber volume produced by sawmill in 6 weeks is:

$$\frac{10{,}000 \times 6}{52} \times \frac{60}{100} = \pm\ 692\ m^3\ (\text{S.W.E.})$$

$$\frac{692\ m^3}{2m\ \text{height} \times 0.8\ \text{density}} = \pm\ 433\ m^2$$

Total area of air drying yard, plus roadways and circulation, ranges between 5 and 7 times the stack area depending on yard configuration. Therefore, for single species storage of ± 692 m^3 of lumber closely stacked, allow 433 x 6, or approximately 2,600 m^2 for the yard area. If species separation is made, then somewhat more area may be needed depending on the proportion of each species, say ± 3,000 m^2.

If yard drying time is greater or less than the assumed 6 weeks, then the yard area should be adjusted proportionately.

It can be seen from the above that air drying yard area is a function of both the sawmill output rate and the drying time. Thus, a 20,000 m^3 sawmill would need double the area for the same drying time.

3.2.2.3 Building Area

The area occupied by the sawmill, offices, workshops, power unit, sanitary facilities, fire water pond and circulation roads is usually no more than about one hectare for the size of sawmills under consideration.

3.2.2.4 Log Pond

For those sites where log storage is in a log pond, the area of water surface may be estimated as follows:

i. Assume an average log inventory of about 2,500 m^3 of logs (or whatever is necessary to carry over the expected logging shut-down period).

ii. Assume maximum log length to be 5 m.

iii. Assume average log diameter to be 600 mm.

iv. Assume that all logs are floating in a single layer on the water surface.

v. Assume an average log to water area ratio of 75% (allows for bowed logs, short logs, etc.).

Then, water surface area occupied by floating logs =

$$\frac{2{,}500 \text{ m}^3}{\frac{\Pi}{4} (0.600) \times 0.75 \text{ ratio}} = \underline{\pm 7{,}100 \text{ m}^2}$$

Total area to allow for log moving, boat ways, and circulation ranges between 1.25 and twice the above area, depending on pond configuration. Therefore, for single species storage of 2,500 m^3 logs allow 7,100 x 1.6 or ± 11,400 m^2 for the pond area.

If a species separation is to be made in the log pond for 2,500 m^3 of logs, then somewhat more area may be needed so that the inventory of each species may be built up without overlapping into the area assigned to another species group. Hence, if three species group separations are made, the log pond area may have to be increased to approximately 14,000 m^2.

3.2.2.5 Examples of Site Areas

i. Log supply 10,000 m^3/A; yard 2,500 m^3
3 species sorts
Air drying time, 6 weeks

a) Log yard	15,000 m^2
b) Air drying yard	3,000 m^2
c) Building area	10,000 m^2
Total =	±28,000 m^2

ii. Log supply 10,000 m^3/A; pond 2,500 m^3
3 species sorts
Air drying time, 6 weeks

a) Log pond	14,000 m^2
b) Air drying yard	3,000 m^2
c) Building area	10,000 m^2
Total =	±27,000 m^2

iii. Log supply 20,000 m^3/A; yard 5,000 m^3
2 species sorts
Air drying time, 8 weeks

a) Log yard, 15,000 x 2	30,000 m^2
b) Air drying yard, 2,600 x 2 x $\frac{8}{6}$	7,000 m^2
c) Building area	10,000 m^2
Total =	± 47,000 m^2

iv. Log supply 20,000 m^3/A; pond 5,000 m^3
2 species sorts
Air drying time, 8 weeks

a) Log pond 13,000 x 2	26,000 m^2
b) Air drying yard, 2,600 x 2 x $\frac{8}{6}$	7,000 m^2
c) Building area	10,000 m^2
Total =	± 43,000 m^2

3.2.3 Site Layout

The site should be arranged to promote an orderly flow of raw materials and products. Logs should be delivered to the log storage areas without obstructing other traffic in the sawmill area. Sorting, if required, would be carried out in the storage areas and logs would be transported to the infeed deck to maintain an adequate supply for the headrig. Similarly, the output of lumber from the green chain should be moved to the drying yard, then to finished storage and shipping area. (See figures 1 to 3.) If the site is located in an area surrounded by forest, a firebreak 30 m wide should be left clear around the entire perimeter of the mill property.

3.2.4 Log Storage

Log storage may be in a log yard, a log pond, or both, depending on the methods used to deliver logs from the forest.

The small mobile or portable sawmill in a clearing close to a road construction area needs only a few days inventory of logs, supplies being dependent on the logs extracted during the course of road construction. Such a wood supply is often variable since difficulties in terrain or unexpected bad weather may slow down road construction and consequently reduce the flow of raw materials.

Sawmills with log supplies of 10,000 to 20,000 m^3/A are designed to operate five or six days a week continuously, with at least one shift of 8 or more hours working time per day. Under these conditions the log storage capacity must be sufficient to allow the sawmill to function at normal levels during periods when log extraction is interrupted by seasonal bad weather or when forest workers temporarily leave their jobs to cultivate their own crops.

3.2.4.1 Log Storage Volume

The log storage volume may be estimated in the following manner:

i. Calculate number of full operating days in one year

Total days in year		= 365
Annual vacation shut down	= 14 days	
Weekend non-producing days, 50 x 2	= 100 days	
Religious and statutory observances	= 11 days	
	125	125
Production days per year		240

ii. Daily log volume requirements

$$= \frac{10{,}000\ m^3}{240\ \text{days}} = 41.67\ m^3 \text{ per day}$$

iii. If the number of working days during which logs cannot be delivered to sawmill is 60 days, the minimum log inventory at start of a 60 day period is 60 x 41.67 = 2,500 m^3 logs.

iv. The rate at which logs must be delivered to the mill in order to build up the inventory over a one year period is as follows:

Total mill workings days	= 240
Non-delivery days	= 60
Days when logs can be delivered	= 180 days
Annual volume needed	= 10,000 m^3
Therefore, daily delivered volume	=

If the species mix of logs is such that it is desirable to segregate them into separate groups for sawing, drying and marketing, then the ratio of each species group to total log supply must be determined and the quantities for inventory estimated as above.

3.2.4.2 Log Storage Arrangements

The arrangement of the log storage area should be designed to accommodate the following requirements:

i. Segregation by species according to end-use and sawing characteristics (if necessary).

ii. Sorting of each species into groups by diameter and length, if the delivered logs are of variable sizes.

iii. Orderly use of inventory to prevent excessively long storage periods, especially in the case of species highly susceptible to fungal stain or insect damage.

iv. Development of properly aged stock piles of sufficient quantity to carry over periods when logging is not possible.

v. Separation of piles to reduce hazard of fire spreading from pile to pile.

vi. Ease of moving logs from storage to the sawmill infeed.

3.2.4.3 Log Yard

The log storage yard should be positioned near the log infeed of the mill so that travel distances are minimized. The surface should be cleared and grubbed to remove all topsoil, stumps and large roots. A top dressing of unsorted gravel and sand should be laid and compacted to a depth of about 200 mm to form a base for the roadways and assist in checking regrowth of weeds.

To reduce the deterioration of logs during storage, **stockpiles** should be regularly sprayed with water or stored in log ponds. (See 3.3.1)

Travelled roadways should be surfaced with graded crushed gravel to provide a well-drained running surface under all weather conditions. About 250 mm of gravel surface is normally sufficient, although this quantity may vary according to local conditions.

Roadways and stacks should be aligned so that heavy rainfall drains away from the site.

Stacks of logs should be supported off the ground on longitudinal decay-resistant logs. This will keep sand and gravel off the log surfaces, thereby reducing damage to saws.

The method of estimating log yard area is described in 3.2.2.

3.2.4.4 Log Pond

The log storage pond should be positioned so that the maximum volume of logs are as close as possible to the log infeed of the mill.

Although an existing body of water may be large enough to accommodate the required volume of logs, several other factors should be evaluated. For example, consider the following:

i. Deep water makes it difficult to recover logs which sink while in storage.

ii. Fluctuating water levels may prevent movement of logs into the mill during periods of low water.

iii. Strong water currents during times of flooding may carry away logs from storage.

If a log pond is to be constructed, the most economical shape is a circle or, to a lesser extent, a square. The water should not be deep, provided it is sufficient to float the largest or heaviest logs. A shallow pond facilitates recovery of logs which are stored submerged or which sink while in storage.

Logs are hauled from the pond into the mill along skidways, which should be positioned directly in front of the sawmill infeed. Log channels lined with long floating logs chained together serve to lead the sawlogs in an orderly manner towards the skids. The logs in the channels should be oriented so that they approach the skidway without having to be turned. The skidway should deliver them on to the infeed deck in the correct position for loading on to the carriage.

3.3 Log Protection and Handling

3.3.1 Log Protection

Logs in storage need protection from fire, insect and fungus attack and deterioration due to uneven drying.

The characteristics of the species and local conditions will determine whether logs are best stored with bark on or off and whether the log stacks should be sprinkled with water or left dry. The major advantages of sprinkling the log stacks include protection from fire and a reduction of the incidence of insect and fungal damage. Sprinkling also reduces end checking and log-splitting and gives a more uniform moisture content which improves the sawing properties.

Small mobile or portable sawmills using about 5,000 m^3/A of logs normally require only minimal fire protection because the period of log storage is relatively short.

Mills processing 10,000 to 20,000 m^3/A have larger log inventories and therefore regular sprinkling is important. If the site is surrounded by heavy forest, a firebreak about 30 m wide should be cleared around it.

3.3.2 Log Infeed

The equipment required to transfer logs from the storage yard to the log infeed deck can be simple and relatively inexpensive.

For the mobile or portable sawmill processing about 5,000 m^3/A animal power can be used to pull a simple sleigh carrying the logs. The logs should not be dragged directly on the ground as this inevitably results in sand and stones being embedded in the surface of the logs, causing expensive damage to saws and severe loss of production time.

For the sawmill processing about 10,000 m^3/A a simple "jammer" or log-carrying truck can be used. This need be nothing more than a substantial truck chassis with a hoist frame and winch on the back to lift and carry the logs to the infeed deck. Alternatively, a number of logs could be loaded on to a simple trailer and towed to the log infeed deck.

For the sawmill processing about 20,000 m^3/A similar equipment can be used, but in larger numbers to handle the increased volume. It is difficult to justify the use of large, heavy duty, log-carrying fork trucks in this size of operation since they require large manoeuvring areas and good all-weather roads, in order to withstand the high wheel loads which such vehicles impose. They are also very expensive to purchase and maintain.

3.3.3 Log Infeed Deck

The log infeed deck is an arrangement of supports leading to the position where logs are loaded on to the headrig carriage. The incoming logs are placed on the supports parallel to and in line with the log loading position. (See Plate 2.)

The supports may be comprised of skids set on a slight downward slope, over which the logs roll or slide by gravity to the loading position, or they may be horizontal chain ways with a powered feed controlled by the head sawyer.

At the loading position it is necessary to have substantial log stops to prevent logs from falling into the carriage travel zone. The log stops are frequently combined with log loading arms designed to assist the movement of the log from the infeed deck on to the log carriage. Log turning devices are frequently installed as part of the infeed deck.

3.3.4 Log Cleaning

Prior to loading on to the log carriage for the first cuts the logs should be inspected for embedded stones, sand or scrap metal. This is best done in an area just ahead of the actual log infeed deck so that the workers removing these objects are not exposed to any moving equipment. A water spray is very useful for washing away sand and grit on the log surface.

Plate 3 Circular sawmill headrig with top saw

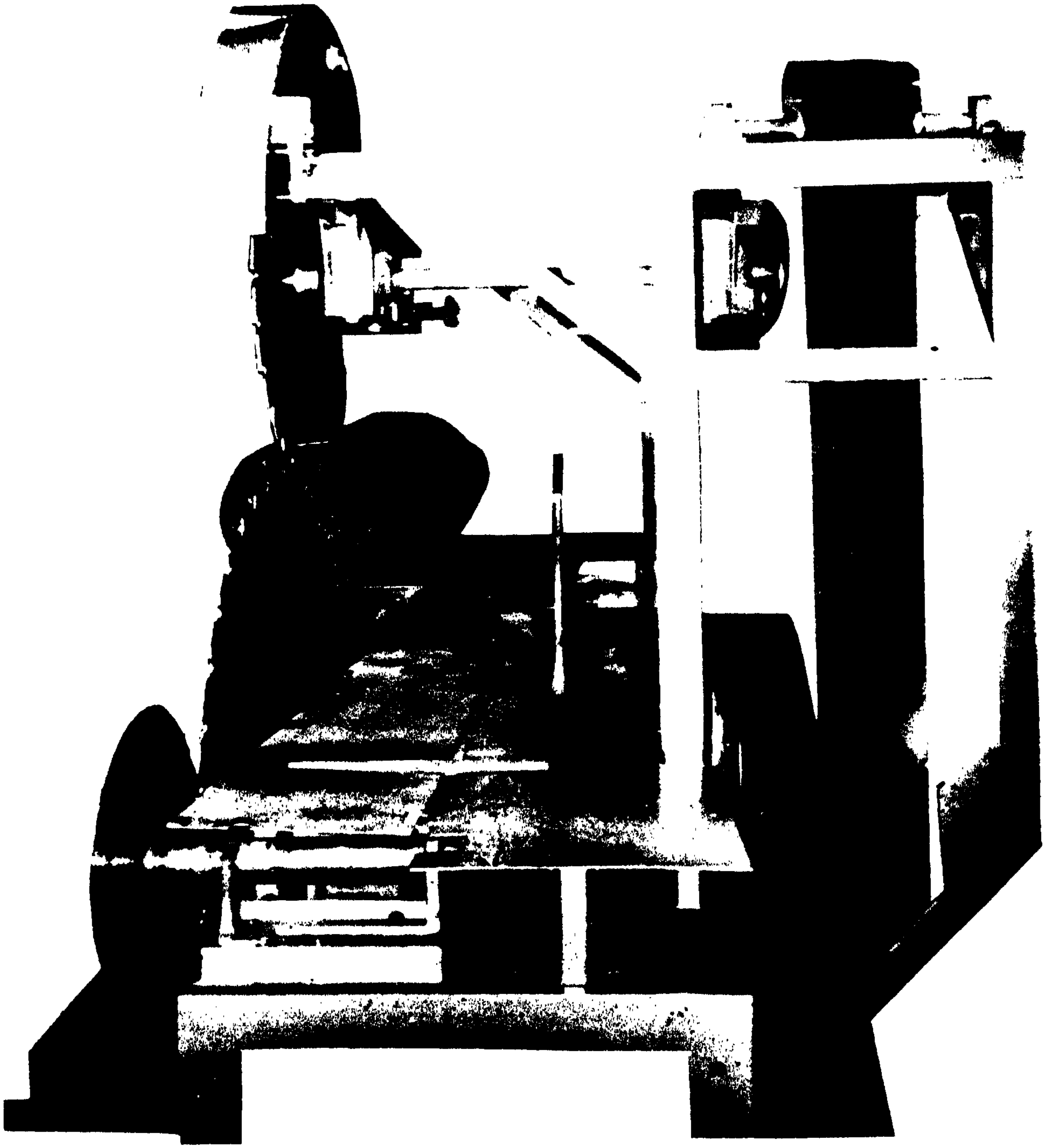
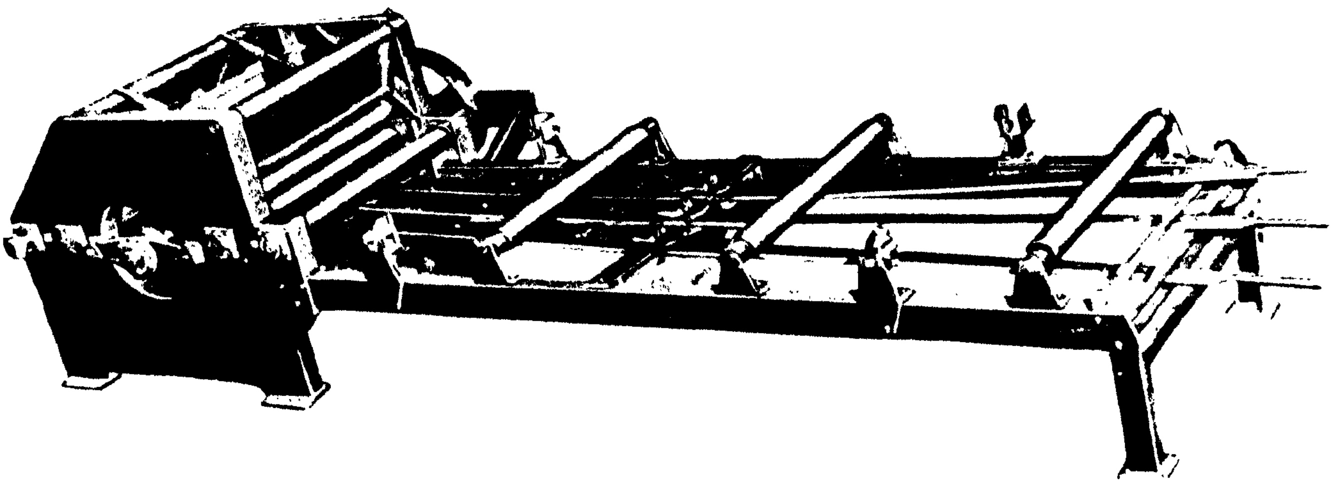


Plate 4 A small two-saw edger



3.3.5 Log Debarking

The debarking of logs has advantages in that it reduces damage and wear on the headsaw caused by sand and stones, which often become imbedded in the bark during logging, transportation and handling in the mill yard. A reduction in wear on the headsaw gives longer time intervals between saw sharpening and, consequently, higher production per shift, as well as reduced saw sharpening costs. A bark-free log can also be evaluated more effectively by the head sawyer and this should improve the grade of the lumber produced.

Debarking may be carried out by unskilled labour, using hand tools before the logs reach the infeed deck. Alternatively, mechanical debarkers may be used, installed ahead of the infeed deck.

In assessing the feasibility of debarking, the cost of this operation has to be related to the estimated value of the benefits outlined at the beginning of this section. For the sizes of sawmills considered in this guide, however, mechanical debarkers are generally too expensive to justify their use, unless a market for waste wood develops for pulp production. For this purpose the waste wood must be free of bark.

In the event that the addition of a mechanical debarker is justified, there are four types to be considered:

i. Chain flail

ii. Rosser head

iii. Cambial

iv. Ring.

Chain flail debarkers are not suitable for removing stringy bark and the cambial and ring types are both expensive to purchase and maintain. The rosser head debarker is generally the most effective for use in small sawmills.

3.4 Machinery Required

An appropriate type of headrig for a mobile or portable sawmill would have a circular headsaw 1,200 mm to 1,500 mm in diameter, that would cut maximum log diameters of 650 mm to 850 mm. Inserted tooth saws are satisfactory for a wide range of species and are relatively easy to maintain.

The manually set edger would have two circular saws of about 500 mm diameter to cut thicknesses of up to 150 mm.

A single swing or slide crosscut saw would perform any cutting to length. In the early stages of development much of the lumber could probably be marketed without end trimming.

A diesel engine rated at 130 kW would be adequate. It would consume about 13 litres of fuel per hour of production.

A mill for 10,000 m^3/A log supply should have a circular headsaw of 1,500 mm diameter, plus a top saw of 1,000 mm diameter, to accept logs with a maximum diameter of 1,200 mm. (See Plate 3.)

A manually set edger with two circular saws of about 600 mm diameter to cut thicknesses of up to 200 mm would be required. (See Plate 4.)

A two-saw "Mountain Type Trimmer" would perform all grade and length trimming for planks and boards. A single swing or slide crosscut saw would be used for timbers. (See Plate 5.)

Log handling from log yard to headrig infeed deck could be carried out by animal power, or a simple hoist-equipped log-carrying truck. From water storage logs could be handled using a skidway equipped with a cable and winch.

A diesel engine rated at 150 kW would provide power for the mill. It would consume about 15 litres of fuel per hour of production.

A mill for a log input of 20,000 m^3/A would have the same headrig as the 10,000 m^3/A mill, but with more power to the saws allowing faster feed speeds. A resaw with 1,000 mm diameter saw would share the ripsawing load with the headrig. Edger and trimmers would be the same as for the 10,000 m^3/A mill, but a longer sorting table would be necessary after the trimmer. More rollcases, transfer tables and by-product conveyors would assist in moving lumber and keeping the operating floor clear.

Power requirements would rise to about 250 kW and could be provided by two 130 kW diesel-electric sets consuming about 26 litres of fuel per hour of production.

3.4.1 Log Sawing or "Breakdown"

When a log is loaded on to the carriage of a headsaw the sawyer must position the log in the best orientation for the sawing pattern he wishes to use. The general configuration of the log also has a significant influence on the position in which it is placed.

Another major factor to be considered is whether, in a given species, the good wood is on the outer surface of the log or in the centre of the log. When the good wood is at the surface, the log must be positioned on the carriage so that any longitudinal taper is taken up on the carriage knees and the face of the log to be cut runs parallel to the sawing line. If the good wood is in the centre of the log, the carriage knees should be adjusted so that the longitudinal axis of the log is parallel to the sawing line.

When the log has a pronounced "sweep" from end to end, the first cuts are usually made with the sweep positioned in the vertical plane.

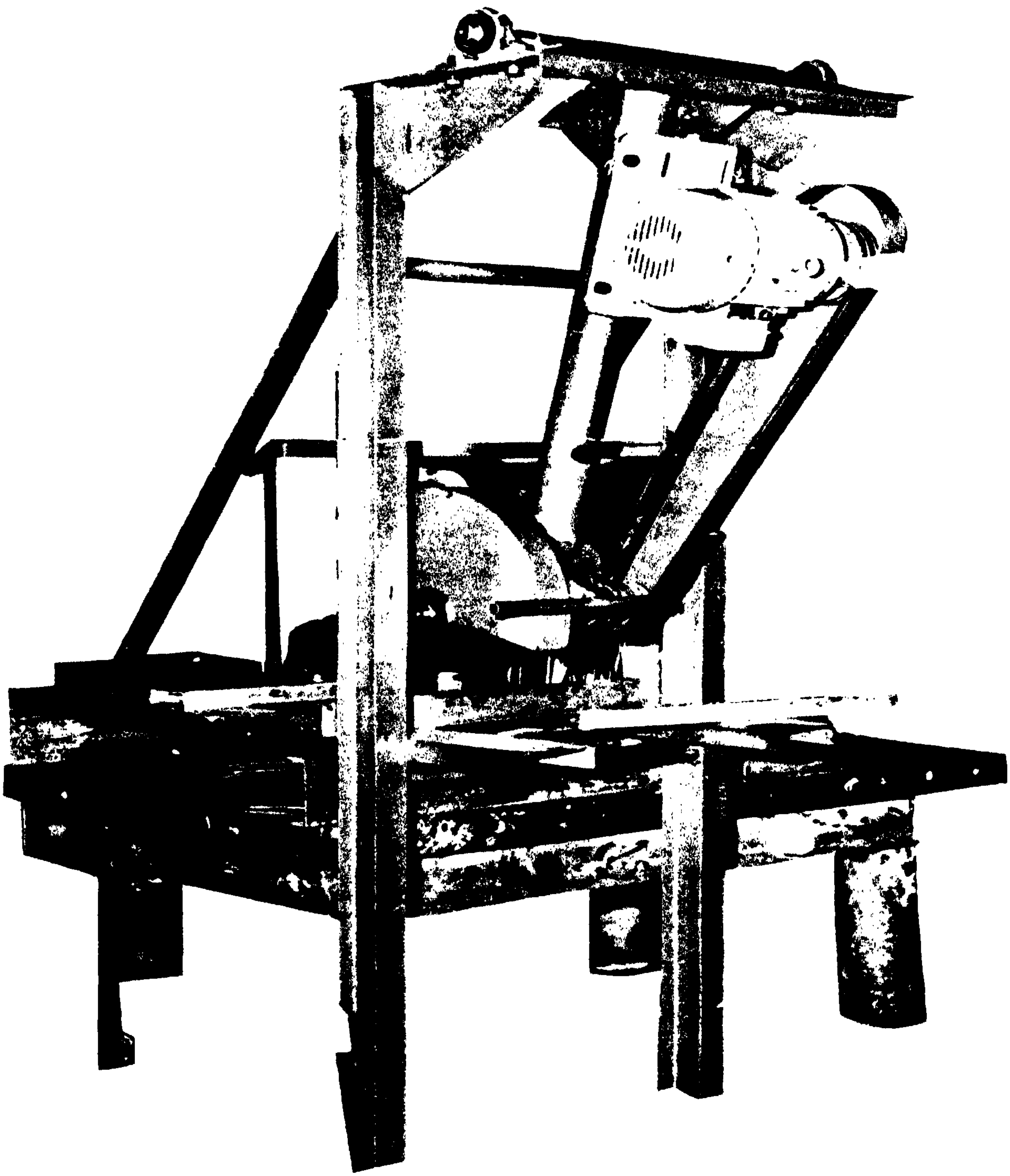
3.4.1.1. Sawing Patterns

The sawing patterns to be followed are based on the market requirements in an area. In some areas, the market appears to demand a very wide range of thicknesses and widths of lumber and this practice can often be attributed to the versatility of very small sawmills and pit-sawing operations which, in the past, could afford to cut for the specific requirements of each customer.

In order to obtain high lumber recovery and provide for the widest markets, it is usually necessary to rationalize the sizes of lumber to be cut. Standardized thicknesses and widths should be established in ranges that permit larger sizes to be further broken down by remanufacturing saws.

Within the terms of reference adopted for this guide the principal output of the small and medium-sized sawmills will be construction type lumber, with the following dimensions and suggested end uses:

Plate 5 Swing saw used for trimming lumber



i. Boards of about 25 mm thickness and in widths from 100 mm to 300 mm in 25 mm or 50 mm increments. These are suitable for concrete formwork, roofing, flooring and box making.

ii. Planks of about 50 mm thickness and in widths from 100 mm to 300 mm in 50 mm increments. These are suitable for framing lumber for concrete formwork, house frames, small building frames, floor joists, roof rafters and furniture.

iii. Timbers with thicknesses of 75 mm to 300 mm in 25 mm or 50 mm increments and widths from 75 mm to 300 mm also in 25 mm or 50 mm increments. These are suitable for posts, beams, girders, railway ties, mining props and for remanufacturing in secondary industries.

In a small mobile or portable sawmill cutting 5,000 m^3/A of logs, the normal output would be primarily planks and timbers of the larger sizes. This usually provides the most economical operation for this type of mill and permits the largest volume of good lumber to be moved to the market as quickly as possible. Figure 4a indicates the type of sawing pattern which could be used.

In a sawmill with 10,000 m^3/A log supply the machinery is of heavier construction and greater power. It will produce the full range of sizes suggested above at a faster rate and with better accuracy than the mobile or portable mill. The number of cuts to be made on the headrig is the limiting factor in mill production. Figure 4b shows a typical sawing pattern for a mixture of boards, planks and timbers which will ensure a good recovery of lumber from the log.

In a sawmill with 20,000 m^3/A log supply the primary rip-sawing load is shared between the headrig and the resaw and more power is applied to the saws to achieve the required production rates. The full range of suggested sizes can be produced. Figure 4c shows how the same cutting load as in Figure 4b can be shared between the headrig and the resaw. The edger load remains the same.

The sawing patterns illustrated are only examples of certain types; patterns actually used can only be developed after the market requirements have been defined.

For the small percentage of logs with a diameter too large for the headrig, special sawing patterns may be required. The oversize logs should be split into quarters by sawing lengthwise with a suitable chain saw or by splitting with wedges. Each quarter is then loaded on to the carriage and broken down in a manner similar to the examples shown in Figures 4d and 4f.

For those logs with severe rot in the centre, or hollow logs, other patterns must be developed to recover lumber from the sound annulus. (Figure 4e).

It must be emphasized that the foregoing comments on sawing patterns have, of necessity, only touched lightly on the subject. It is beyond the scope of this guide to go into greater detail.

FIGURE 4 - CUTTING DIAGRAMS

HARD WOOD

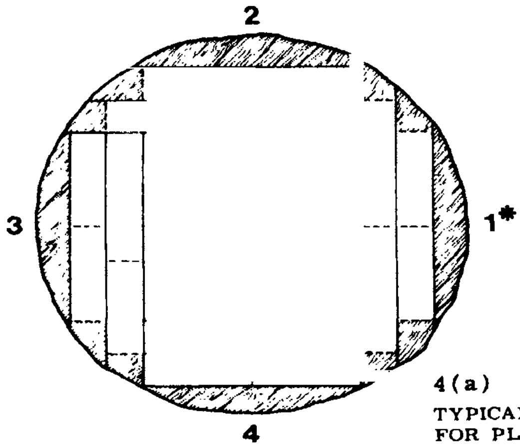
600 mm O log

No. of cuts/machine

* Cutting sequence

Headrig ——— 12

Edger - - - - - 16(10)

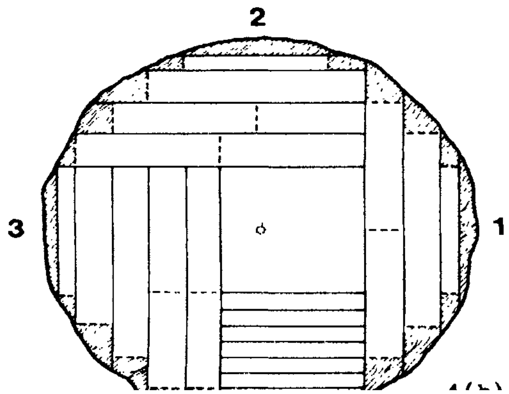


4(a)

TYPICAL CUTTING PATTERN FOR PLANKS AND TIMBERS

Headrig ——— 23

Edger - - - - - 22(14)



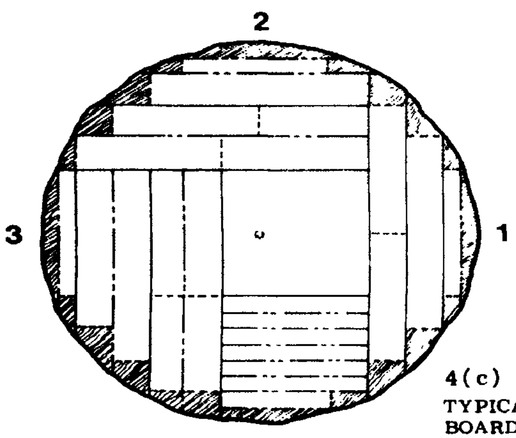
4(b)

TYPICAL CUTTING PATTERN FOR BOARDS PLANKS AND TIMBERS

Headrig ——— 9

Resaw —-—-— 14

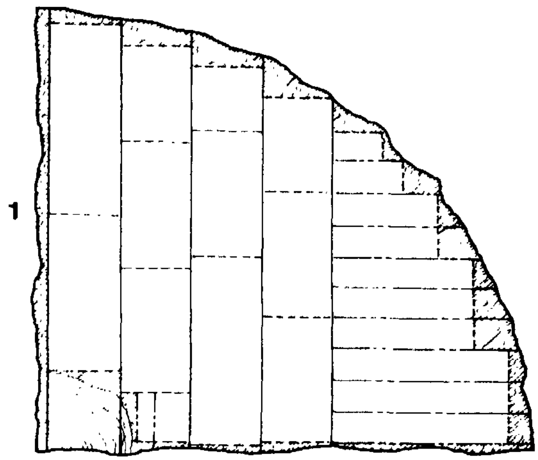
Edger - - - - - 22(14)



4(c)

TYPICAL CUTTING PATTERN FOR BOARDS PLANKS AND TIMBERS USING HEADRIG AND RESAW

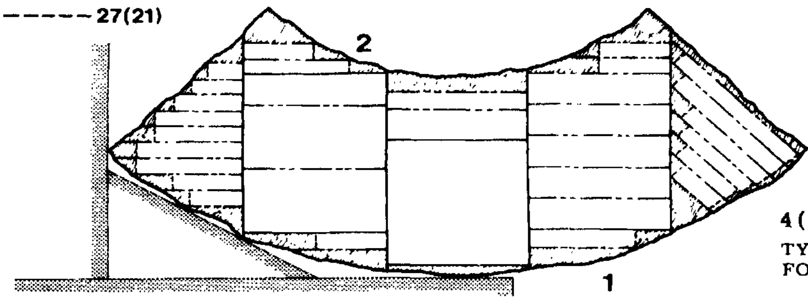
Headrig ———— 5
Resaw —·—·— 13
Edger - - - - - 27(14)



4(d)

TYPICAL CUTTING PATTERN FOR QUARTERED LOG WITH HEART ROT

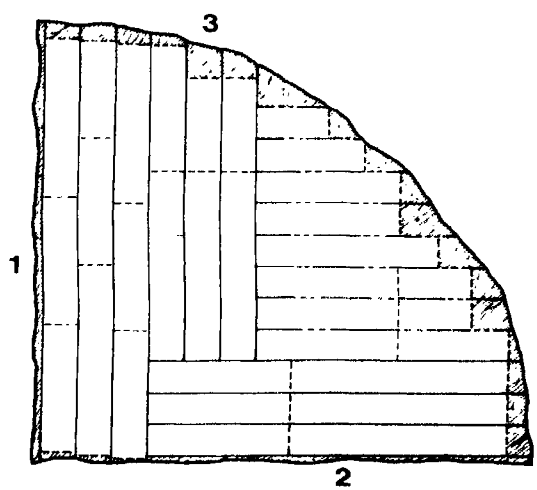
Headrig ———— 9
Resaw —·—·— 32
Edger - - - - - 27(21)



4(e)

TYPICAL CUTTING PATTERN FOR QUARTERED HOLLOW LOG

Headrig ———— 11
Resaw —·—·— 8
Edger - - - - - 35(21)



4(f)

TYPICAL CUTTING PATTERN FOR QUARTERED SOUND LOG

3.4.1.2 Breakdown Machinery

The primary breakdown machine in the sawmill is the headsaw. There are many types of machines and each has a suitable place depending on the volume and species of logs to be converted. A list of some types of headsaws suitable for small mills is provided below:

i. Mechanical drive version of pit saw.

ii. Chain saw with guided longitudinal travel.

iii. Horizontal band saw on carriage travelling the length of the log.

iv. Horizontal band saw with travelling log carriage.

v. Circular saw headrig and log carriage.

vi. Band saw headrig and log carriage.

In order to process the volumes of logs specified for this guide and to produce well manufactured lumber of specific dimensions at a consistent rate, the choices narrow down to either the circular saw headrig and log carriage, or the band saw headrig and log carriage.

These two types were chosen because the basic sawing techniques are the same from the smallest mobile or portable sawmill to the permanent sawmill processing up to 20,000 m^3/A of logs. Hence, a sawmilling operation starting with a small volume of logs can be upgraded progressively as the log supply increases by adding more sawing capacity. Also, there is no extensive retraining of operating personnel required. Furthermore, these two types of headrigs produce more accurate and uniform lumber and there is less wastage of wood in the form of sawdust, particularly in the case of the band saw.

3.4.1.3 Circular Saw Headrig

The circular headsaw is simple, strong and reliable and is easy to operate and maintain. Proper maintenance and good saw sharpening permit cutting accuracy and uniformity which are entirely suitable for the end uses stated earlier in this guide.

Depending on the size of logs to be cut, either a single saw or two saws mounted one above the other in the vertical plane can be used. (Plate 3.)

As saw diameter increases the width of the "kerf" or saw-cut increases and a higher proportion of wood is lost as sawdust. Generally, circular saws with diameters in excess of 1,500 mm are more difficult to maintain and operate. Typically, a saw 1,500 mm in diameter with solid swaged teeth will produce a kerf of 8.7 mm, while a saw of the same diameter with inserted point teeth will produce a kerf of 10.3 mm.*

3.4.1.4 Band Saw Headrig

The band head saw in its modern version is a strong and reliable machine. It requires more skill in operation and maintenance than does the circular headsaw. Proper maintenance and saw sharpening permit better cutting accuracy and uniformity than the circular headsaw.

To cut logs with a diameter of 1,200 mm, a saw with wheels of approximately 2,400 mm diameter is needed. The saw blade runs in the vertical plane and is about 200 mm to 250 mm wide.

Band saws usually produce a narrower kerf, typically about 4.6 mm for a saw suitable for the mills cutting 10,000 m^3/A and 20,000 m^3/A log supply.

*Quelch, P.S., "Sawmill Feeds and Speeds".

3.4.1.5 Log Carriage

The log carriage must be large enough and strong enough to traverse the maximum size log through the chosen headsaw. A log 1,200 mm in diameter and 5 m long would weigh between 2,800 and 5,700 kg depending on species and moisture content.

As the log rests on the carriage it must be firmly clamped by top and bottom "dogs" to prevent movement during sawing. A setting mechanism controlled by the sawyer advances and retracts the log in relation to the sawing plane. The supports and clamps must be capable of adjustment so that either the log axis or the log surface can be set parallel to the sawing plane. For the range of log lengths contemplated in this guide, either three or four sets of knees and clamps would be satisfactory. Log turning devices allow the sawyer to position the log correctly on the carriage for the best sawing pattern.

Loading, log turning, clamping, taper positioning and setting can be performed by hand or by power-operated devices. In a small mobile or portable sawmill with 5,000 m^3/A log supply, hand power is usually acceptable. In a sawmill with 10,000 m^3/A log supply, some form of simple mechanical power device to assist in loading and turning the logs would be an asset. In a sawmill with 20,000 m^3/A log supply, a form of power setting is usually required to achieve the required level of production.

3.4.1.6 Machinery Selection

The final choice between the circular headsaw and the band headsaw will depend on the following factors:

i. Capital cost.

ii. Availability of trained personnel to operate and maintain the machinery.

iii. Availability of trained personnel to sharpen, tension and maintain the saws.

iv. Estimated value of extra wood volume lost to sawdust on circular headsaw compared with band headsaw.

The small mobile or portable mill for 5,000 m^3/A log supply is only available with the circular headsaw within the cost range previously stated.

For the other mills of 10,000 m^3/A and 20,000 m^3/A log supply, it is suggested that the circular headsaw is also the logical choice. The work of the saw sharpening department will be simpler and overall maintenance will be easier and less expensive. It is difficult to justify the higher capital cost of the band headsaw for the production of general utility types of lumber.

3.4.1.7 Headrig Rollcase and Transfer

As each piece is sawn off the log at the headsaw, it is deposited on to a rollcase for transport to the next work position. Frequently, a transfer table is combined with the roll case so that the pieces can be moved sideways for temporary storage, as well as longitudinally. A reversible transfer table can be used to temporarily hold large flitches or cants from the headrig and then reload them back on to the carriage for further breakdown.

For a small mobile or portable sawmill with 5,000 m^3/A log supply, a simple landing table is usually incorporated into the complete pre-built unit and the pieces are moved to the edger by hand.

A sawmill with 10,000 m^3/A log supply should have a headrig rollcase extended in length to deliver timbers to the cross-cut saw and a transfer table leading to the edger infeed.

A sawmill with 20,000 m^3/A log supply would require a similar arrangement plus a second transfer table leading to the resaw.

3.4.2 Resaw (See Plate 6.)

A resaw shares the rip-sawing load with the headrig. Slabs, flitches and cants from the headrig go to the resaw for further breakdown into planks and boards. The resaw allows a second look at each piece of wood and consequently higher grade material can often be found and recovered.

Thick slabs from the headrig can be resawn parallel to the wide face so that, when the board is edged, lumber recovery is improved.

Flitches or cants with two or three sawn faces from the headrig can be resawn into planks and boards, some of which may not require further edging.

The resaw should be positioned in the mill so that it can receive from both the headrig and the edger. It should be able to deliver to the edger, to the sorting table, and by return to its own infeed.

Since the resaw is always cutting smaller pieces than the headsaw, it can be operated with a thinner saw, reducing the amount of wood lost as sawdust.

The resaw can be either a bandsaw or circular saw. (The advantages and disadvantages of these two types were discussed in 3.4.1.6.) It is usually advisable to stay with one type of saw throughout the mill.

Only the sawmill with 20,000 m^3/A log supply should require a resaw. It would be equipped with line-bar and feed rolls and a saw of 1,200 mm in diameter, cutting to a depth of 430 mm.

3.4.2.1 Resaw Infeed and Outfeed

The transfer table from the headrig rollcase should have "stops" which allow pieces to be accumulated ahead of the infeed to the resaw. The infeed should be of sufficient length to support and guide the longest pieces. A line-bar or fence of similar length is recommended to assure accurate cutting. The position of the line-bar relative to the saw plane is adjustable as required, to establish the thickness of the piece being sawn.

An outfeed rollcase removes the pieces emerging from the resaw. The good piece continues forward to be edged or trimmed. The "off-piece" can be returned to the resaw infeed for further sawing, or sent to the edger or the trimmer.

3.4.3 Edging

The edger consists of two, three or more saws which make parallel cuts through the thickness of the pieces coming from the headrig and resaw. It is used to remove the rough, rounded edges and cut the remainder into standardized widths as required by the market. It may also be used to cut off a strip of defective wood from a board or plank in order to improve the overall grade of the piece. The majority of edgers use circular saws.

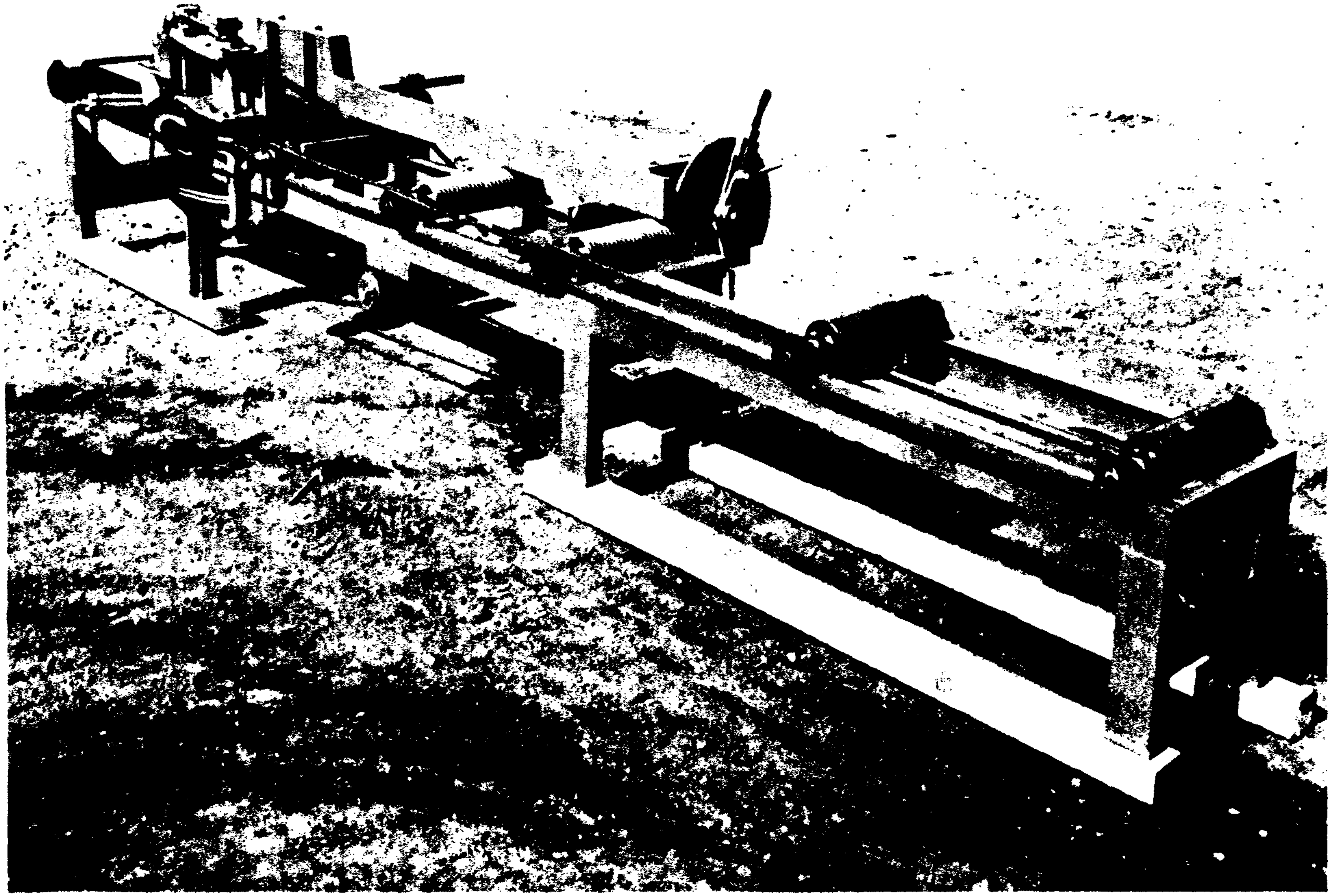


Plate 6 Circular linebar resaw, hand adjustable

The edger must be able to receive material from the headrig and the resaw. It delivers lumber to the sorting table where pieces can be sent back to the resaw or back to the edger or continue on to the trimmer.

The small mobile or portable sawmill for 5,000 m^3/A log supply usually has a two-saw edger included in the complete unit. A saw with a diameter of about 600 mm can edge up to 150 mm in thickness. The movable edger saw and fence are met by hand.

For the sawmill with 10,000 m^3/A log supply, a two-saw edger with 700 mm saws is required. It can edge up to 200 mm thickness. More power is applied to the saws to permit faster cutting. The movable saw and fence are set by hand.

The sawmill with 20,000 m^3/A log supply can use a similar two saw-edger. However, it requires more power for faster cutting and to allow power-assisted setting of the movable saw and fence.

3.4.3.1 Edger Infeed and Outfeed

The transfer table from the headrig rollcase should have stops which allow pieces to be accumulated ahead of the infeed to the edger. The edger infeed should consist of a power-driven rollcase of sufficient length to support the longest pieces. It should be wide enough so that the widest pieces from the headrig can be positioned for best sawing.

An outfeed rollcase supports the pieces emerging from the edger and thereby assist in maintaining accurate cutting. The good pieces continue forward to trimming. The "off-pieces" may be returned for further edging or may be sent back to the resaw. The edgings are pulled off on to the residual removal system.

3.4.4 Trimming

The trimming operation can perform several functions:

i. Trim ends of boards, planks and timbers square to the longitudinal axis.

ii. Trim boards, planks and timbers to standard lengths according to market demands.

iii. Trim off defects so that the overall grade is enhanced and market value improved.

In some instances trimming is not required. There is often no need for trimming if the lumber is to be remanufactured into other items. Furthermore, local markets may be such that standard length increments and finished ends are unnecessary. If conditions of this nature are present, then it is an obvious advantage not to trim at all.

In situations where an improved quality of finished lumber will significantly increase the price, it is usually advantageous to trim off gross defects near the ends of pieces. The end product is shorter but the quality is higher and therefore of greater financial value

3.4.4.1 Trim Saws

Trim saws are available in many forms. Some of the suitable types are:

i. Overhead mounted swing cross-cut saw.

ii. Overhead mounted slide cross-cut saw.

iii. Under mounted swing cross-cut saw.

iv. Two-saw trimmer.

v. Multiple saw trimmer.

The overhead swing saw comprises a saw arbour or shaft mounted in a swinging frame suspended over the trimming position. The swing axis and the saw axis are parallel to each other so that the saw cross-cuts the lumber in the plane of swing. (Plates 5a and b) The saw can be driven by belt drive from a line shaft or by direct electric motor drive.

The overhead slide saw comprises a direct motor-driven saw mounted on a carriage which travels on tracks supported above the trimming position. The tracks are positioned parallel to the plane of the saw so that the saw cross-cuts the lumber in the plane of sliding.

The under-mounted swing saw is similar in construction to the overhead swing saw, except that the swing shaft is mounted at floor level.

All three of the above saws have a retracted position so that the revolving saw blade is completely clear of the area through which the lumber passes. The cutting stroke is usually made by hand power but mechanical methods are available. These saws can trim between 5 and 15 pieces per minute.

The two-saw trimmer or "Mountain Trimmer" is equipped with a lug-chain table containing several strands of lug-chain about four or five metres long. An under-mounted saw is positioned to one side of the chains a short distance from the infeed. The trimmerman pulls each board onto the table so that the lug-chain carries the piece through the saw where it is trimmed. After leaving the first saw a set of rolls takes each board across the table to the second trimmerman, who positions each piece to pass through the second saw, which is mounted on the side opposite from the first saw. This type of machine can trim up to 25 boards per minute.

The multiple saw trimmer consists of a number of overhead mounted drop saws spaced apart at standardized distances. Each board is carried by a group of lug-chains under the saws. Special detectors, or operator controls, bring the appropriate saws down into position while the board is traversed through the sawing zone. Both ends of the board are trimmed simultaneously. Having completed the cut, the saws return automatically to their raised position, ready for the next board. This type of machine trims up to 40 boards per minute. It is the most expensive of the group.

For mills with an input capacity of up to 10,000 m^3/A only the first three trim saws listed above need be considered. All are simple, robust and reliable and can achieve the required levels of production.

The small mobile or portable mill with 5,000 m^3/A log supply often does not require a trimmer for the types of planks and timbers being produced. Where it is necessary to cut long pieces in half for handling, a hand saw or chain saw will suffice, if the numbers are low. Otherwise, an overhead single swing cross-cut saw would be capable of meeting the workload.

The sawmill with an input capacity of 10,000 m^3/A will require three trim saws of the overhead swing or slide cross-cut types to process all pieces, including timbers. It is important to position them strategically to accommodate the efficient flow of wood in the mill.

The sawmill with an input capacity of 20,000 m^3/A would require to have a two-saw or Mountain Trimmer for all boards and planks and one overhead cross-cut saw for timbers.

3.4.4.2 Trim Saw Infeed and Outfeed

Pieces from the resaw and the edger are deposited onto a transfer table leading to the trimming position. This allows the pieces to be examined and sent back to either resaw or edger, as required. It also permits edgings and waste pieces to be pulled off into the residual collection system, to avoid impeding the trimming operations.

After trimming, the pieces continue along a similar transfer table to the grading position and then to the green chain.

The tables are usually comprised of four or five strands of flat-topped mill chain running in chainways and powered by a small electric or mechanical drive unit. The spacing of the chains is arranged to support all lengths of lumber expected to be produced in the sawmill.

3.5 Sorting, Grading and Treating

3.5.1 Sorting

After trimming, boards and planks move to the sorting or "green" chain. Depending on markets and end-use, there are different levels of intensity of sorting. These include the following:

i. Sort by thickness only.

ii. Sort by thickness and width.

iii. Sort by thickness, width and length.

iv. Sort by thickness, width, length and grade.

v. Sort by thickness, width, length, grade and species.

Within the terms of reference used in this guide, relatively simple sorting techniques are adequate. A sort by species is often the most important one.

If the species mix in the log supply is such that there is little difference in end-use, then it is normally satisfactory to leave all species mixed in the final products. On the other hand, if there is wide variation in species characteristics and distinct differences in end-use and market price, then a species sort is necessary.

To simplify species segregation at the sorting, chain logs should be sorted in the log yard. This allows separate production runs for each group, facilitating the selection of appropriate saw teeth, feed speeds and cut sizes. The sawing of each species group is consequently carried out with a high degree of efficiency.

Within each species group the characteristics of density, strength, colour, drying and end-use should be similar in order to simplify processing and marketing.

Assuming that species groups will be processed separately, an appropriate method of sorting the finished lumber, in keeping with the end-uses described in this guide, is as follows:

Grades: Numbers one, two and three.

Size: By width and thickness, with random lengths in each size.

Under normal conditions, a sort of this nature will accommodate the sale of green lumber direct to the market and the building of stacks for air drying.

The sorting chain, or "green chain" consists of four or five rows of mill chain, spaced in line with the trimmer chains. The length of the chain must be sufficient to accommodate grading and to give workers enough room to remove pieces from the chain onto the stacks of lumber.

3.5.2 Grading

The decision as to whether or not the lumber should be graded for quality will depend upon market requirements. As outlined in 3.4.1.1, the principal product contemplated is construction type lumber; an alternative will be secondary industrial use. Accordingly, three grades would be appropriate. These are listed below along with their principal characteristics:

Number One Grade: This grade would deal primarily with appearance. The product should have good grain; few, if any, small tight knots; no decay; no insect holes.

Number Two Grade: This would be essentially a building or strength grade. The finished lumber should meet the following specifications: slope of grain not exceeding 1:8; sound tight knots not exceeding one quarter the width of face or 50 mm, whichever is less; insect holes not exceeding 5 mm.

Number Three Grade: This would be a utility grade where major defects can be trimmed away during remanufacture. Virtually all lumber not included in the first two grades would fall into this category, provided it has been sawn on the four faces.

It must be stressed that the above grades are only general suggestions. Actual grading rules must be established locally to suit local conditions, species, markets and end-uses.

Once the grading rules are established, it is necessary to train the personnel working on the sorting chain to inspect and mark each piece according to its appropriate grade. In the early stages of a sawmill development programme the rules should be kept as simple as possible until personnel develop grading skills.

The costs of grading lumber must be recovered in the selling price of the lumber. Therefore the selling price for each grade must include the cost of labour and the value of all lumber edged and trimmed off to meet the grade.

3.5.3 Dipping and End Treatment

The purposes of dipping and treating ends of freshly sawn lumber include the following:

i. Dipping in a suitable solution protects stacked lumber and, in some instances, the finished product from fungal and insect attack.

ii. Dipping also creates more uniform coloration in the lumber, thereby allowing some mixing of different species.

iii. End treatment is intended to retard end drying and reduce the incidence of checking and splitting.

iv. In summary, lumber cut in most tropical and sub-tropical areas should be protected against fungi and insects. Local conditions and species characteristics should be assessed when determining the method of treatment.

3.5.3.1 Dipping

Dipping for protection from mould, fungi and insects requires chemical solutions adapted to both the species being protected and the hazards being guarded against. Information on solutions is freely available from major suppliers. Such solutions are often strong enough to cause skin irritations; the labourers who work with the solutions or handle treated lumber should be suitably protected.

Dipping for colour uniformity requires solutions that are adapted to the species being treated. Frequently it is possible to combine this treatment with dipping for protection. Colour solutions may also cause skin irritation.

Methods of applying solutions to freshly cut lumber include the following:

i. Hand brushing the solution on to each piece.

ii. Hand spraying each piece.

iii. Hand dipping each piece.

iv. Mechanical dipping of each piece.

Hand brushing and hand spraying are only suitable when small quantities of lumber are being treated.

Hand dipping involves the use of a long, narrow trough placed across the chain table ahead of the final sorting section. Each piece is picked up at the ends by two operators using tongs and is placed in the solution in the trough. The piece should be rotated and submerged to ensure complete wetting. After dipping it is lifted out and placed on skids for a few minutes to allow draining. The solution draining off the pieces returns back to the dip tank.

Mechanical dipping is accomplished by installing a wide trough beneath the carrying chains so that the chains dip below the surface of the liquid. Lumber on the chains is pressed below the surface by an overhead, slotted drum. After draining, the lumber goes to the final sorting chain. (See Plate 7.)

Care must be exercised to ensure that solutions dripping from stacks of boards do not contaminate drinking water, food supplies or streams. Great care is also needed when storing and handling the chemicals and when disposing of spent solutions.

3.5.3.2 End Treatment

End treatment normally involves a brush or spray application of paint or wax solution to seal the end grain of the lumber. With the solution in place, air drying proceeds largely from the flat faces of the lumber; drying at the ends is slower and more uniform.

The end sealant can be applied before the lumber reaches the sorting chain or after it has been stacked. It is easier to seal before sorting if pieces of different lengths are being treated. When treating stacked lumber, all pieces in the stack must have the same length so that both ends are accessible.

It is usually difficult to treat ends of freshly dipped lumber. The wet surface may not accept the sealant unless it is correctly formulated to be compatible with the dipping solution.

Plate 7   Automatic lumber dipping vat with slatted rollers for hold down

In the case of sawmills with an input capacity of 5,000 m^3/A, located close to the forest and producing lumber which is sold green to the market, dipping and end treatment are usually unnecessary. However, there may be small quantities of high quality lumber which would benefit from end sealing.

For the sawmills with an input capacity of 10,000 m^3/A and 20,000 m^3/A, any lumber sold green could be left untreated. Lumber to be air dried should be end treated. Since the air drying stacks will all be built with spaces between layers of boards, it may not be necessary to dip the lumber. However, the spacers should all be dipped to discourage fungi and insects at the contact areas. If green lumber is to remain tightly stacked for more than a few days, it should be dipped.

3.6 Drying

After the lumber is sorted and stacked it may be sold green or dried to an acceptable level.

Drying accomplishes the following:

i. Reduces the weight of lumber for subsequent transportation.

ii. Stabilizes the lumber dimensions for subsequent end use.

iii. Develops desirable colour or strength characteristics.

Drying can be accomplished by natural (air) drying or forced drying in heated or refrigerated kilns.

Each species of wood has a unique cellular structure and, therefore, drying techniques vary according to species. To obtain optimum drying results, species should be sorted into groups with similar drying characteristics.

Within the context of this guide air drying has a number of advantages. Capital is not required for kilns and heaters, the added flexibility allows different species to be dried separately and the process can be easily controlled by local personnel. On the other hand, air drying requires a greater land area for drying yards, there is an increased fire risk due to the large lumber inventory and there is a large amount of capital tied up in the inventory.

For the end-uses contemplated in this guide, air drying appears to be an adequate means of reducing weight and stabilizing dimensions.

In preparation for drying the lumber should be stacked at the sorting chain into rectangular packages. "Stickers" or spacers of uniform thickness should be placed between each layer. The stickers improve the stability of the lumber stack and allow two or more stacks to be placed one above the other, thereby conserving yard space. A fork lift truck is of great assistance in transporting lumber stacks to and from the drying yard and in loading trucks for shipment.

The tops of lumber stacks should be covered with some type of portable roof to ensure that the top layers of boards do not dry too rapidly in the sun. The weight of the roof also helps to hold the boards flat and reduces distortion. The roof should hang over the sides and ends of the lumber stack to provide adequate shade.

The air drying yard should be located in a place with a good flow of air at all times. It should be removed as far as possible from any source of flying sparks from the sawmill or outside the mill site. Weeds should be controlled.

In some countries traditional air drying methods involve standing the pieces in a vertical "X" configuration on drying racks. This is usually done to develop desirable coloration. For many species and end-uses this type of stacking produces poor results. Since the boards are almost completely unrestrained in the X's, cupping, bowing and twisting are quite common. This significantly reduces the value of the lumber. Furthermore, the land area required is greater and many man hours are wasted making the X's and repiling the lumber after drying. Hence, this system should be avoided.

If species groups are segregated in the log yard and processed in the mill as units, it is logical to continue the process in the air drying yard. Therefore, a given species group should be assigned a specific section of the drying yard. In this manner, appropriate drying times can easily be maintained for each species group.

3.6.1 Drying Schedules

The time spent in the air drying yard depends on the characteristics of each species group and the end use of the lumber. There is a great deal of information available concerning the drying rates of many species. This information should be carefully studied for guidance. Final moisture content will be determined by end-use. For example, concrete form lumber is satisfactory with a moisture content higher than that of furniture stock.

The final location of the finished product should also be considered. For example, lumber used in a dry, arid area will stabilize at a moisture content lower than lumber in a humid area.

For the types of lumber and end-uses being considered in this guide, the primary objectives should be to reduce transportation weight of finished lumber and to bring dimensions close to a stable condition.

The fastest drying rates occur in the days immediately after sawing the lumber and then decline in subsequent weeks and months. Consequently, three or four weeks of air drying can significantly reduce weight and stabilize dimensions.

3.6.2 Dry Sizes

Dry lumber may be sold on the basis of green (or nominal) dimensions or on the actual measurements when dry. The lateral dimensions of air dried lumber will frequently shrink from 3% to 6%; length shrinkage is usually not significant. Hence, a given piece of lumber, which measures 100 mm by 200 mm green, may measure 97 mm by 194 mm or, in extreme cases, 94 mm by 188 mm when dry. If the market requires the lumber to be 100 mm by 200 mm after drying, then green sizes must be increased accordingly (e.g., to 103 mm by 206 mm, or 106 mm by 212 mm, depending on species and drying schedule).

The selling price of the dried lumber should include the cost of the green size required, as well as the costs of stacking, unstacking for sale, and interest on the value of the lumber while in the drying yard.

3.6.3 Regrading

After drying some species will develop loose knots and end cracks which will affect the grade. In such cases, the lumber can be retrimmed and regraded. However, considering the end-uses covered in this guide, retrimming and regrading can be bypassed during the early years of market development for the products of the mill. These operations can be added later as markets and prices firm up.

3.6.4 Dry Storage

After the lumber of certain species has dried sufficiently it may be necessary to store it under cover, to minimize deterioration caused by excessive exposure to bright sunlight and drying winds. This operation can also be added to the mill after production patterns and markets have been established. Dry storage sheds should be readily accessible from the yards and should be situated to allow convenient loading of trucks. The roof and walls should be weathertight; good ventilation is essential.

If fork lift trucks are not available, manual labour is required to stack the dry lumber. Usually stickers are not necessary between each layer of dry lumber, but should be placed at each sixth layer to help stabilize the piles.

3.7 By-products

By-products produced by the sawmill operations include:

i. Bark; dry from yard logs and wet from pond logs. Periodically there will be mixed bark and gravel from log yard clean-up and saturated bark from log pond clean-up.

ii. Sawdust.

iii. Slabs.

iv. Edgings.

v. Trim ends.

vi. Broken logs, limbs, etc.

Dry bark is often a valuable source of domestic fuel. Wet bark can be piled in a suitable location and allowed to dry for fuel. If the bark cannot be sold or given away as fuel, it can be dumped as land fill or burned as waste.

Sawdust is also a valuable fuel for domestic or industrial use, provided it is not too wet. Some species produce sawdust suitable for use as agricultural mulch or animal bedding. Other species produce sawdust which is objectionable to man and animals. If the sawdust cannot be sold as fuel, it may be possible to use it as fuel in the mill operations.

Slabs, edgings, trim ends, and broken logs are a potential source of raw materials for small secondary or home industries. Alternatively, they can be used as domestic and industrial fuel or, if there is a pulp mill nearby, they can be chipped and sold for pulp mill furnish.

3.7.1 Chips

Conversion of clean mill wood waste to chips can be justified only under certain conditions. There must be a pulp mill within economic transporting distance, the species available be suitable for the pulping process, and there should not be another use for the wood waste offering a higher social or financial return.

The costs of transporting wood chips to a nearby pulp mill can be calculated in the following manner:

i. Estimate the annual volume of chips that the sawmill could produce. (Assume approximately 30% of delivered sound log volume per annum.)

ii. Determine the price that the pulp mill will pay for chips of the quantity, species and quality expected from the sawmill.

iii. Deduct labour costs to operate the chipping facility.

iv. Deduct interest on capital cost of the chipping facility.

v. Deduct transportation costs. (Fuel, depreciation, maintenance, labour, insurance, licences, etc.)

The capital cost of establishing a chipping operation may represent a major part of the capital investment in a small sawmill. Equipment requirements would include the following:

i. A chipper infeed conveyor equipped with a metal detector.

ii. A chipper capable of accepting the largest pieces of waste expected.

iii. A chip screen. (Unscreened chips may either be rejected by the pulp mill, or accepted at a reduced price.)

iv. Chip storage facility. (Chips stored on the ground may not be acceptable to the pulp mill.)

v. Chip conveyor to storage area.

vi. Chip loading facility.

Within the framework of this guide only the larger mills with an input capacity of 20,000 m^3/A have the potential for a chip production facility. It should be remembered that to produce chips of an acceptable quality all logs must be debarked before entering the sawmill. Hand or mechanical bark removal will add further to the cost.

Whenever high quality chips are being produced for pulp furnish a certain amount of supervision is needed to maintain chip quality. This may reduce the emphasis placed on good lumber production and on efficient lumber recovery. The primary objective of the sawmill operation is to produce lumber, not chips.

3.7.2 Waste Disposal

If sawmill by-products cannot be used economically, then they must be disposed of as landfill or burned. Landfill sites should be close to the sawmill. Dry ravines or worked-out quarries are often suitable. Problems associated with landfill disposal include uncontrolled fires within the fill and insect pest build-up. If no suitable landfill site is available, then burning becomes the only alternative. Controlled burning is essential to reduce fire hazards and minimize environmental impact. Simple, natural draft burners are available for this purpose.

3.7.3 Removal of By-products

The most effective means of gathering by-products inside the sawmill is by means of a few strategically placed conveyors. Simple chain conveyors are used to collect sawdust from beneath the headrig, resaw and edger for delivery to a single sawdust storage area. If the sawdust is to be sold off the site, a raised hopper can be constructed to help load the trucks.

If the log supply contains a large percentage of unsound heart or rot it is desirable to have a large waste conveyor near the headrig so that a bad log can be removed quickly without obstructing mill operations.

Small slabs, edgings, trim ends, and broken pieces should be removed from the operating flow on a low level conveyor and delivered to a separate area. From there they can be sold off the site, cut up for fuel or sent for chipping, if warranted.

In small mobile or portable sawmills with an input capacity of 5,000 m^3/A most of the by-product removal operations can be done manually. Sawdust conveyors would help to avoid build-up problems. Sawmills with input capacities of 10,000 m^3/A and 20,000 m^3/A should be designed to accommodate a complete gathering system. Initially, equipment for sawdust removal and edging removal should be installed. The remaining parts of the system can be added at a later date.

3.8 Power Supply

An essential difference between traditional and modern sawmilling practice is the amount of power applied to the sawing process. By applying more power to the saw teeth running at correct speed, more lumber can be produced in a given time period without increasing the work force.

Studies by various authorities* have demonstrated the need for minimum feed speeds and appropriate power loadings for consistent production.

A reliable and adequate power supply is of great importance in sawmill operations. If electrical power is not available, is inadequate for sustained operations or is subject to interruptions, then it is prudent to install on-site equipment for all the mill's power requirements.

3.8.1 Power Requirements

The power required to operate a small sawmill may be estimated from the following table:

Log haul	7 - 10 kw
Log deck (if powered)	4 - 7 kw
Head saw	75 -150 kw
Carriage drive	7 - 10 kw
Log turners	4 - 7 kw
Setworks	2 - 4 kw
Main rollcase	4 - 8 kw
Transfer tables (chains)	10 - 15 kw
Edger infeed or resaw infeed	5 - 8 kw
Edger (two-saw)	10 - 20 kw
Resaw	15 - 20 kw
Edger outfeed or resaw outfeed	4 - 8 kw
Sorting chains	4 - 8 kw
Trim saw	4 - 8 kw
Sawdust conveyor	1 - 2 kw
Edging and slab conveyor	3 - 5 kw

* Quelch, P.S.; Williston, E., etc.

3.8.2 Power Options

The options available for sawmill power plants include the following:

i. Direct mechanical drives from diesel or gasoline engines.

ii. Electric drives from diesel or gasoline-driven generators on site.

iii. Steam engine or turbine drives from steam generated by burning wood waste on site.

iv. Electric drives from steam generators driven by burning wood waste on site.

Diesel power units are generally preferred to gasoline engines for sawmill applications because of their reliability, lower operating costs and reduced fire hazard.

3.8.3 Diesel Power Units

Small mobile or portable sawmills usually have direct mechanical drives from one main diesel engine. A small diesel-electric set provides power for lighting, small tools and small auxiliary drives.

In permanent mills with input capacities of 10,000 m^3/A and 20,000 m^3/A, electric drives supplied from a diesel-electric power unit are the most flexible. Reliability of power supply is improved if two diesel-electric sets of identical size are installed. Furthermore, one set can be turned off during low load periods. The capital cost of two sets is somewhat higher than that of one set, with the same total power, but it is a worthwhile expenditure.

3.8.4 Steam Generated from Wood Waste

The burning of wood waste to generate electric power for mill operation at first glance appears economically attractive, particularly where fuel oil has to be imported. The sale of excess electrical power off-site is also a possibility. However, experience with wood waste burning installations reveals a number of problems which seriously reduce economic expectations. Wood waste with a high moisture content and wet bark are very poor fuels and may even need supplementary fuel-firing to sustain combustion and support the load on the steam system. Fly ash in the flue gas and tars condensing on cool surfaces create environmental and operating problems. The raw fuel itself (hog fuel) is a bulky commodity, awkward to stockpile, retrieve and fire into the boilers.

The capital cost of a wood waste fired plant generating electricity for sawmill use and for sale externally can be expected to be 20% to 40% higher than an equivalent oil fired plant. Factors contributing to the higher capital cost include the following:

i. Excessive costs of receiving, storing, retrieving and firing the hog fuel.

ii. Larger furnace volumes.

iii. Larger fans because of higher gas volumes.

iv. Larger ducts and stacks.

v. Fly-ash collectors.

vi. Standby or supplementary oil fuel storage and firing.

Considering the above constraints only sawmills which are much bigger than those contemplated in this guide can support a wood waste fired plant. Recent studies indicate that, at present fuel oil prices, a log supply volume of at least 180,000 m^3/A is necessary to justify a power plant of this type.

An alternative to a steam-electric installation would be a hog fuel fired boiler producing steam at pressures suitable for direct use in steam reciprocating engines or small turbines. These would drive the sawmill machinery by direct drives or by line shafts and belts. In the past, many sawmills were powered in this way; a large number of them are still operating successfully.

With a lower capital cost than a steam-electric plant, the steam-power plant becomes feasible for sawmills with log supply volumes of 100,000 m^3/A or higher.

The maintenance costs of both steam-electric and steam-power wood waste burning plants are invariably much higher than equivalent capacity oil burning plants.

Recently, by means of gasification, wood wastes have been successfully converted to gas of low calorific value, suitable for combustion in gas turbines or gas engines. The same physical problems involving hog fuel, such as gathering, storing, retrieval and firing, apply to gas producers as well. A log supply volume of at least 180,000 m^3/A is necessary to justify such a capital installation.

3.8.4.1 Water Supply

Small sawmills requiring water only for domestic, sanitary and cooling services could obtain sufficient volumes from small wells or springs and, depending upon the climate, from roof run-off from buildings within the sawmill complex. It is unlikely that any extensive treatment facilities would be required other than chlorination of the domestic supply.

In plants where steam generating facilities might be used, a much larger quantity of water would be required and much more sophisticated water treatment facilities might be involved. Several wells, or a small lake or stream would be required to supply the water. A steam-electric or steam-turbine operated plant would require the least amount of water, since most of the steam generated could be reclaimed as condensate and reused.

The treatment of water for steam generation could include any or all of the following processes: settlement, flocculation, clarification, filtration hardness removal and ion exchange.

Storage of water may also be necessary in the sawmill area both for steam generation and for fire-fighting, storage facilities being generally combined for both purposes.

3.8.4.2 Operating Staff

All power plants producing steam under medium to high pressure require qualified personnel to operate the boilers. In most areas, only operators licensed by appropriate government authorities are permitted to be in charge of such plants. This can create a serious staffing problem if insufficient trained operators are available.

3.9 Support Functions

3.9.1 Accounting

Once a decision has been taken to implement a sawmill project, accounting procedures must be set up for the construction phase, as well as for the management and cost control of sawn timber production.

During the construction period it will be necessary to maintain records of all expenditure for construction, equipment and installation costs so that the progress of the project may be related to the cost estimates for control purposes. Pre-operational expenditures for training and start-up trials of the equipment, for example, must also be recorded since such expenditures are generally capitalized. In order to establish depreciation rates for construction, pre-operational costs and equipment, it will in most cases be necessary to produce financial records acceptable to the taxation authorities.

An accounting system must be established prior to the start-up of mill operations for the following purposes:

i. To give management the essential financial control of operations by comparing results, generally on a monthly basis, with annual budget estimates.

ii. To determine the manufacturing costs of sawn timber.

iii. To provide the necessary documentation to support annual tax returns.

It is important to have accurate figures for manufacturing costs for sawmill operations in order to assess the efficiency of the operations, particularly when comparing the effects of different operating procedures on overall costs.

Manufacturing cost data is also required as a basis for reaching management decisions. For example, when considering the introduction of new or lower quality species manufacturing costs are required, as well as estimates of selling prices, in order to determine the prices that can be paid for logs of such secondary species.

An efficient accounting system requires a regular flow of information from all sections of the operations in order to maintain the necessary records. In addition periodic checks of inventories of logs, sawn timber and operating supplies should be carried out to ensure that the records are in agreement with actual stock levels. Thus, losses due to degrade of logs and sawn timber in storage for long periods, for example, are adjusted in the records at regular intervals.

On a daily basis the flow of information from the operating sections to the sawmill office would include the following main items:

i. Details of species and volumes of log receipts from suppliers and issues to the mill.

ii. Details by species and volumes of sawn timber produced, stacked in the drying yard, and sold.

iii. Receipts and issues of supplies.

iv. Time sheets for all personnel.

The above information, together with records of purchases and sales, is compiled to produce a monthly Profit and Loss statement which indicates the profitability or otherwise of the operation. Such a statement is most important in that it provides the manager and the owners with a summary of the status of the sawmill operations and, by comparing with earlier statements, a measure of the progress and efficiency of production can be obtained.

On an annual basis a Balance Sheet is required for a sawmill enterprise which summarizes the assets and liabilities and gives the net worth of the enterprise. A Balance Sheet may also be required when application is being made for a loan or when changes in ownership are under consideration.

Although the same basic principles indicated above apply to all types of sawmill enterprises the accounting procedures of necessity would be kept as simple as possible for the portable mill operation described in Case 1 of this Guide. The maintenance of daily records might be undertaken by the supervisor in this case using a simple day book to record all transactions for subsequent compilation by a clerk. In the larger mills the daily flow of information would be maintained by foremen. Similarly, in Case 1 operating supplies such as fuel would be charged when purchased, whereas fuel in the larger mills would generally be received in stock and charged only when issued from a storage tank for the mill power plant and/or mobile equipment.

3.9.2 Production Control

Production control is necessary to ensure that the sawmill cuts the sizes, lengths and grades needed to meet the market demands and to fill the sales orders received by the mill. This function also ensures that the logs are cut efficiently so that wood is not wasted as odd sizes or miscut pieces.

By comparing volumes of logs received at the mill with lumber shipped and waste quantities produced, a measure of the overall operating efficiency of the mill can be obtained. Records of production per unit of manpower allow a comparison of levels of performance between work crews and between sawmills.

The accumulated production information is used to prepare annual financial statements and is normally required by government agencies.

3.9.3 Inventory

The inventory includes all logs in the log yards and log ponds and all the lumber in the air drying yards and in dry or open storage awaiting shipment. The amount of wood being processed in the sawmill at any given time is usually very small compared to the yard inventory.

The inventory represents the working capital of the sawmill. Its value includes the price of all logs delivered to the mill, plus all costs of labour, fuel, maintenance, administration, etc., involved in converting the logs into lumber ready for sale. Taxes and licence charges must also be included in the cost price of the lumber. The difference between inventory value of the lumber and the actual market price received when the lumber is sold will determine whether or not the mill operates at a profit or a loss.

Systematic inventory control will also assist in revealing log and lumber losses due to degrade, mismanufacturing or theft.

3.9.4 Maintenance

An organized preventive maintenance programme is vital in keeping a sawmill running steadily and efficiently. Briefly, the principal maintenance functions include the following:

i. Lubricate all items requiring lubrication with the correct lubricant, at the time intervals specified by the manufacturer.

ii. Inspect at regular intervals all items subject to wear and repair or replace them before failure occurs.

iii. Repair and put back into service as quickly as possible all items which fail unexpectedly or are broken in service.

To carry out these functions the maintenance department must have a suitable stock of lubricants, spare parts and tools. Nuts, bolts, washers, cotter pins and similar items are constantly needed; small stocks should always be readily available, kept in a controlled storage area. A small workshop area with some form of overhead lifting tackle facilitates the work of the maintenance department.

Oxy-acetylene equipment for brazing and welding, as well as electric-welding equipment, are usually considered essential maintenance tools. A small lathe and a small milling machine are useful in making replacement parts and shafts, unless an efficient machine shop is operating near the mill. Hand tools for drilling, grinding and sawing are also necessary.

Most manufacturers of machinery provide a list of suggested spare parts which may be purchased along with the main items. Unless the mill has ready access to spare parts, these packages should be purchased. Electrical spare parts should include fuses, starters, motors, wiring, light bulbs, and so on.

For the small mobile or portable sawmill with an input capacity of 5,000 m^3/A, a portable maintenance facility can be established on the deck of a suitable truck. Small parts should be kept in lockable cabinets.

Sawmills with an input capacity of 10,000 m^3/A and 20,000 m^3/A should include a suitable workshop area. If capital is not available initially, a workshop should be incorporated into the plans and added to the sawmill at a later date. Machinery parts are expensive and require safe, covered storage to prevent deterioration or loss.

3.9.5 Despatching

Proper despatching requires a well organized system. Each despatch should be a written or verbal order which specifies the quantity, length and grade of lumber, the truck, the destination, and the arrival date. Only a few key personnel should have the authority to issue such instructions. The yard despatcher should be authorized to check to make sure that all aspects of the instructions are met.

The trucks are to be loaded by hand and simple machine. The load should be secured to prevent movement in transit.

3.9.6. Administration/Management Facilities

Considering the sizes of mills contemplated in this Guide, more than one function of administration and management can be assigned to one person. For example, marketing or sales of lumber could be combined with overall mill management. Accounting, time-keeping, payroll and invoicing may be another combined responsibility. Suitable offices are required for administration and management personnel.

Since the salaries of all office staff are included in the overhead cost of lumber produced, it is important that the number of staff be kept to the essential minimum. In some instances a shortage of suitably qualified people can help to minimize the number of office personnel.

The small mobile or portable sawmill with an input capacity of 5,000 m^3/A usually requires only two managerial personnel, one man at the site and the other in an office in the local community. Sawmills with an input capacity of 10,000 m^3/A may require three qualified people and the mill with an input capacity of 20,000 m^3/A can usually operate with four staff members. It is better to start with a small staff and add as necessary, rather than hire a large staff and find it impossible to cut back.

A suitable allowance for office space is about 10-14 m^2 per person, including space for passageways, filing cabinets, desks, etc. Washing and sanitary facilities should be provided for both office and mill personnel. Lunchrooms and first aid facilities are also required.

4.0 PERSONNEL

4.1 Personnel Requirements

In order to operate a small sawmill on a sound economic basis the number of employees must be limited to the minimum number that can perform all the essential functions efficiently. This means that many members of the staff must be able to perform more than one function.

Personnel requirements can be broadly separated into operating and non-operating personnel as described in the following sections.

4.1.1 Operating Personnel

This group of employees has the responsibility for all the physical operations involved in receiving, sorting and handling the logs; in sawing the logs into the finished lumber; in handling the lumber for sorting, drying and preparation for sale; in maintaining the sawmill machinery and building in good operating conditions and in maintaining the site in secure, low fire hazard condition.

The members of this group require different levels of skill and may, for convenience, be grouped as follows:

i. Skilled personnel

ii. Semi-skilled personnel

iii. Unskilled personnel

Skilled personnel are those generally considered to be qualified tradesmen and having a background of appropriate training and experience. Examples would be the saw doctor, the maintenance mechanic, the head sawyer.

Semi-skilled personnel are those having some training and experience in the work being performed, but still subject to supervision and further training. Examples would be edger operator, trim saw operator, truck driver.

Unskilled personnel are those having little or no previous sawmill experience but who are capable of following instruction in a conscientious and reliable manner. Examples would be lumber pilers, log handlers, cleaners.

In a small mobile or portable sawmill with a log input of 5,000 m^3/A the duties of saw doctor, maintenance mechanic and head sawyer could probably all be performed by the one skilled man. Two semi-skilled men would run the edger and trim saw and four or five unskilled men would handle logs and pile lumber.

For a sawmill with an annual log input of 10,000 m^3 the duties of saw doctor and maintenance mechanic would be carried out by one man. There would be a head sawyer who could assist the saw doctor when necessary and three semi-skilled men would run the edger, trim saws and grading. Six or seven unskilled men would handle logs and pile lumber.

A sawmill with 20,000 m^3/A log supply would require three skilled men to carry out the duties of saw doctor, maintenance mechanic and head sawyer. Five semi-skilled men would run the edger, resaw, trim saws and grading, and nine or ten unskilled men would handle logs, pile lumber and clean up.

4.1.2 Non-Operating Personnel

This group of personnel has the responsibility for the marketing, management and administrative functions which would include the following duties:

i. Acquisition of logs.

ii. Marketing of finished lumber.

iii. General management of all operations.

iv. Record keeping.

v. Time keeping.

vi. Payroll.

vii. Accounting.

viii. Hiring and dismissal of personnel.

ix. Public relations.

x. Secretarial.

In the size range of sawmills contemplated in this guide some staff members will be required to perform more than one of the above functions. The ability to read, write and perform arithmetical computations is a prerequisite for the development of the skills required to carry out the above functions.

For convenience, staff may be classified as trained or partly trained. Trained staff for sawmill work should have previous experience in sawmills. Examples would be the general manager, the log buyer, the lumber salesman. Partly trained staff need not have had previous sawmill experience. Examples would include the record-keeping, payroll, accounting and secretarial personnel.

The general management, log acquisition, lumber marketing and public relations functions could probably all be performed by one experienced man in a small mobile or portable sawmill. All other functions could be carried out by one or two partly trained staff.

In a sawmill with 10,000 m^3/A log supply the addition of a third, partly trained person, to those listed above would probably be adequate.

A sawmill with 20,000 m^3/A log input would require two experienced men to carry out the functions of log acquisition, lumber marketing, public relations and general management. All other functions could be performed by three or four partly trained people.

4.2 Salaries and Wages

The establishment of appropriate salary levels and wage scales for sawmill personnel requires a detailed assessment of all applicable government regulations and, in areas where some industrial activity already exists, of prevailing rates being paid for work comparable to sawmill activities.

If a sawmill is to be established in a remote area where regular, paid employment is not customary, then care must be exercised in studying the social effects on the community. In such cases employees are often provided with staple foods, lumber for house construction, for example, as part of their compensation.

However, unless the sawmill is to be established as an instrument of social policy, the small mills contemplated in this guide should not become involved in constructing housing, schools, hospitals, etc., as the associated costs may render the entire operation uneconomic.

4.3 Availability and Training of Personnel

In regions where some sawmilling activity of a similar type already exists the establishment of a new sawmill may provide suitable opportunities for advancement of people working in junior positions in existing mills. Advertising vacancies in a new mill should then produce candidates for operational functions and for further training.

Where little or no sawmilling activity has previously existed it would be necessary to bring in key personnel from outside the area. Such key personnel might include, depending on the size of the sawmill, a sawmill manager, saw doctor, maintenance mechanic, and head sawyer, all of whom would have had experience in the type of sawmilling envisaged and in the training of counterparts, as well as all other categories of sawmill personnel.

Once a decision is taken to install a sawmill it is essential that the key personnel be on site so that all organizational matters, log supply and marketing arrangements are ready for mill start-up. Training of personnel would also take place as far as possible during the mill construction period. Such procedures would result in the mill being in production at the earliest possible date.

In addition to the organizational and training functions of key personnel as indicated above, they may also be involved in the design and construction supervision of a sawmill.

Key personnel might be employed on permanent or fixed term contractual basis. In the latter case, the duration of contracts would depend on the time required to fully train counterparts who would, in turn, be responsible for continuing the training of other mill personnel.

For the saw doctor, maintenance mechanic and head sawyer some vocational training at suitable facilities away from the sawmill area may be a necessity. Selected individuals could be sent away for such training and on-the-job experience during the time the sawmill is being constructed.

Some manufacturers of sawmill machinery are prepared to send their skilled representatives to assist in setting up the machinery and in the initial training of operators. The costs for this service are frequently negotiated at the time of purchase of machinery.

5.0 LEGAL ENVIRONMENTAL AND SAFETY CONSIDERATIONS

5.1 Legal Aspects

An important aspect in the early planning of any sawmill is to determine the nature and impact of any government legislation or regulations which may directly or indirectly affect the development. Obviously, legislation and regulations will vary considerably from country to country but the following are representative of the many factors that must be considered before undertaking any detailed development:

i. Land tenure - length, security and cost.

ii. Labour laws - hours of work, minimum wages, workmen's compensation, health and safety regulations, housing, schooling and medical facilities.

iii. Building permits, codes and regulations.

iv. Taxes, tax incentives and subsidies.

v. Financial regulation - foreign exchange control, foreign equity participation and repatriation of profits.

vi. Import and export controls, regulations and duties.

vii. Government charges - licenses, royalties, scaling fees.

viii. Immigration laws and work permit regulations.

ix. Restriction on vehicle weights and speeds with respect to the use of public roads and bridges.

The foregoing and possibly many other laws and regulations will affect, in some measure, the location and structure of any sawmill, be it small, medium or large.

5.2 Environmental Aspects

Within the past two decades environmental issues have received increasing attention. In the developed world there is an ever-increasing volume of legislation directed toward pollution control and the same process will undoubtedly follow in the developing countries. No sawmill development should, therefore, be undertaken in today's world without due consideration being given to its effect on the environment.

Any sawmill produces a large volume of residues in the form of bark, sawdust, slabs, trim ends and other solid wood waste. Disposal or utilization of this waste can result in air, land and/or water pollution. Chemicals used for the preservation of lumber are a further potential source of pollution and sawmills are notorious as "noise polluters". Often pollution control measures can be simple and relatively cheap if they are included in the initial design and planning of a sawmill. However, if consideration of these factors is deferred and the waste is left to accumulate until public concern or government intervention force action, then such remedial measures can be very costly.

If the sawmill is directly tied to a logging operation, a further and perhaps more complex set of environmental factors must be considered. These involve such problems as erosion control, watershed protection, reforestation and maintenance of forest soil nutrient levels.

5.3 Safety

The sawmilling industry has had in the past a very poor safety record in many countries. The potential exists within the industry for serious accidents because of:

- transportation of large and heavy logs and flitches which lead to heavy manual work.
- the use of machinery designed specifically to cut.

However, in the last couple of decades there has been a concerted effort by both unions and management to reduce the frequency and the severity of accidents. The experience of many countries has demonstrated that a relatively safe sawmilling industry is achievable provided that the danger potential is recognized. Some developed countries have written very detailed manuals and guides on the guarding of machinery in order to protect employees from injury. Some literature is available from UNIDO.

Like the environmental aspects described above, specific guarding of machinery and other safety actions should be taken from the commencement thereby instilling a safety awareness in staff right from the start.

6.0 STRUCTURES

6.1 General

The structures to be considered for small sawmills may be divided into sub-structure and super-structures.

Sub-structures include foundations, machinery supports and working floors which are necessary for the installation of equipment to ensure stability and accurate sawing throughout a sawmill.

Super-structures include walls, roofs and enclosures to protect staff and machinery from the effects of prevailing weather conditions. In dry, arid climates, for example, sun shading of the work areas may be the first criterion and walling requirements would be minimal, whereas in areas subject to windstorms, both super-structure and sub-structure must be designed to resist uplift forces caused by high winds.

In areas subject to heavy rainfall conditions the large quantities of run-off water from the roof must be gathered and conducted away from the mill to avoid affecting the sub-structure. In zones subject to earthquakes, both super-structure and sub-structure must be designed to acoommodate the expected seismic forces.

Good ventilation is essential at all times and can be achieved by means of pitched roofs with louvred vents at the ridges. Heavy wire screens used as walling may be desirable for security reasone and to reduce the entry of animals and/or birds without impeding ventilation.

The safety of employees must be considered when planning a sawmill and hazards reduced to a minimum. Measures must be taken as far as may be practicable to protect employees from machinery and conveyors.

6.2 Structural Materials

There is a clear economic advantage in using locally available structural material as much as possible. Wood is usually one of the most readily available and most versatile materials and the local forest resources should be studied to determine those species having the appropriate physical properties and durability for construction purposes.

Wood of adequate structural strength and having resistance to insect and fungus attack, either naturally or as a result of chemical treatment, may be used for the majority of sub-structure and super-structure framing. Certain species may be suitable for direct use in the soil for foundations. Structural connections must be designed to meet the capabilities of the wood in tension, bending, shear and compression for bolted and nailed joints.

Portland cement is usually available and, given a reliable source of clean, graded sand and gravel, it is possible to produce adequate concrete with simple equipment and hand labour. Simple foundations can reduce the need for reinforcing steel by using more concrete in the form of mass or anchor blocks with appropriate anchor bolts.

Corrugated, galvanized steel or aluminum sheets are an economical and durable cladding material for roofs and walls. They can be easily installed over wood framing and need no expensive fastening systems. Purpose-made galvanized nails and washers give a life expectancy equal to that of the sheets. Many years of successful use in all climates has proved the value of this material and it has the further advantage of being non-combustible.

For the sizes of sawmills contemplated in this guide, structural steel and precast concrete appear difficult to justify unless there is a source of supply near to the site.

From the point of view of safety for the people working in the sawmill and the capital invested in machinery and buildings, the use of licensed civil or structural engineers to design and inspect construction of sub-structure and super-structure is strongly recommended. Government regulations may require such professional advice in areas subject to earthquakes or typhoons.

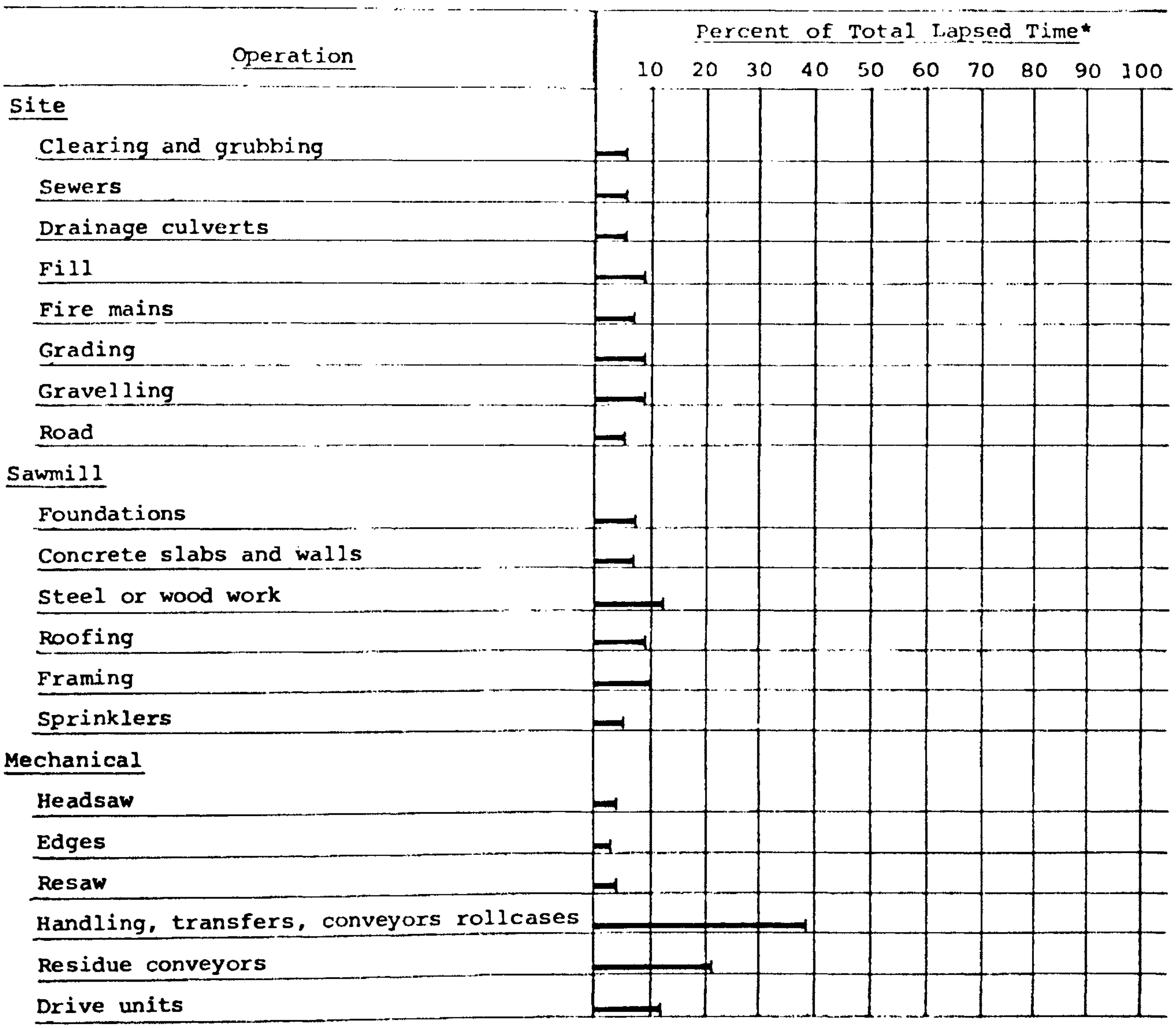
7.0 CONSTRUCTION PHASES

The many stages through which a sawmill project develops from the initial feasibility study to the start-up of production is best illustrated by means of a planning network diagram. A generalized planning network is set out in Figure 5 showing the logical sequence as well as the inter-relationships of the various phases of development. In planning even the smallest mill a diagram of this type should be prepared with realistic start and finish dates for each phase. It is essential that these dates represent what can reasonably be achieved under the conditions prevailing at the proposed site. By following this procedure obvious difficulties or inconsistencies can be spotted and rectified at an early stage in the planning of a project.

Having prepared a planning network and also having obtained general agreement from other participating organizations or companies a project construction bar chart as illustrated in Figure 6 should be prepared. In an actual situation this schedule should be graduated on the horizontal axis in weeks and months. Since this cannot be done on anything but an actual project basis, Figure 6 shows the format and items to be considered with the approximate proportion of total construction time which they will require.

These diagrams need not be elaborate and can be done by hand; the important thing is that the various phases are carefully thought out and achievable targets set.

FIGURE 6 - PROJECT CONSTRUCTION SCHEDULE



*Based on time for operation compared to total construction period. Many of these operations can take place simultaneously and thus total is more than 100.

8.0 COST ESTIMATES

8.1 General

Once tentative decisions have been reached with respect to the most appropriate milling process and equipment, given the previously developed resource and market data, the developer must now begin the process of assessing the project's financial feasibility. The first step in this process is to prepare estimates of capital investment and operating costs. The validity of subsequent financial analysis and profit projections will be directly related to the quality of the cost estimates.

In developing cost data for the purpose of assessing feasibility, the following general guidelines should be followed:

i. Ensure that all areas of project related costs are identified and included.

ii. Determine, in general terms, the relative significance of the various cost elements and concentrate on these during the actual estimating process.

iii. Attempt to develop a broad awareness of the uncertainty which applies to the cost estimates in order to better assess project risk.

The quality of cost estimates can be seriously impaired when inadequate attention is given to the preceding considerations. Thus, for example, cost associated with items such as start-up, worker transport and housing, maintenance materials and spare parts, interest during construction, power line hook-up, connecting roads or raillines, design fees, construction supervision, administration and working capital are often overlooked. Also, there is danger that a disproportionate amount of estimating time and effort be spent on relatively unimportant items or in developing accuracy levels, for easily obtained data, which are far beyond those attainable for more significant cost elements.

Finally, it is important to avoid the pitfall of assuming a degree of estimating precision which does not exist in reality. Some understanding of the probable cost estimating tolerances which apply is most helpful in making final decisions as to whether or not to proceed with the project. For prefeasibility purposes an accuracy level of ±20/25 percent for investment estimates is usually acceptable. Given the potential impact of such variation, it is particularly important that the estimating uncertainty be recognized in order that it can be taken into account in the analysis of financial feasibility.

8.2 Sources of Information

At the outset, the developer is cautioned against utilizing cost data which have been prepared for other sawmills. While such information can be useful as a broad guide, each sawmill situation is different and costs, even at the preliminary level, should be developed from basic data specific to the selected site, process and equipment.

Information requirements for cost estimating will differ with the size and complexity of the proposed sawmill. Similarly, the availability of information will vary depending upon the degree of local industrial development and the extent of support services such as general contractors, equipment manufacturers, building material supply outlets, etc. In many situations it will be necessary to import a major portion (if not all) of the mill process equipment, in which case cost estimates will require international correspondence and the subsequent determination of freight, handling, currency exchange and import duty. In general, the most likely sources of cost information will include the following:

i. Local commercial building and construction contractors, steel fabricators and machinery manufacturers.

ii. International suppliers of sawmill process equipment. In the case of a "portable" mill, it is common for the entire operating unit to be sold as a complete package, thus obviously simplifying the estimating procedures. For medium-size mills, it is likely that a variety of estimates will be required from foreign manufacturers in order to best satisfy the process equipment requirements as previously determined. Names and addresses of foreign equipment suppliers can be obtained from local consulates or embassies.

iii. Local sawmills and panel products mills for manufacturing and construction cost data and specific information with respect to construction and start-up considerations.

iv. Other local industries, such as cement plants, fertilizer plants and oil refineries for construction costs, operating costs, fuel oil prices, labour training requirements and general advice.

v. Local representatives of international organizations such as the FAO, the World Bank and the Asian Development Bank (ADB) for general local information, international contacts and the results of studies and projects undertaken in allied fields.

vi. Central, State and Municipal Government Departments for information with respect to labour rates and legislation, construction regulations and costs, foundation conditions, land availability, electric power availability and cost and possible opportunities for government assistance through grants, loans, tax concessions or similar development incentives.

8.3 Capital Cost Estimates

8.3.1 General

Capital costs or "fixed investment" include the following elements which in aggregate represent the total capital investment required for the proposed project:

i. Land and ite development.

ii. Structures.

iii. Process and ncillary quipment (purchase and installation).

iv. Construction Overhead.

v. Engineering Costs.

vi. Working Capital.

vii. Pre-Operating Expense.

viii. Capitalized Interest Expense.

ix. Contingency Allowance.

Each of these elements will be discussed briefly in the following sections.

8.3.2 Land and Site Development

The costs of purchasing and preparing the selected site must be estimated. While this is a relatively simple task, the estimator should be alert to any special situations which may apply. Building regulations may require the provision of site-related services which are greater in scope, or cost, than the minimal requirements envisaged by the developer. These can include water mains, sewage systems, drainage systems, fire protection, flood control, worker housing and amenities. Special legal fees can be incurred in situations involving the lease or purchase of land which has existing ownership complexities such as multiple owners, estates and so forth.

Soil and foundation conditions can be critical to the development of an effective mill. Particular attention should be paid to potential flooding situations, erosion of adjoining hillsides or river banks, the possible need for piling or special footings under the main items of process equipment, the need for pre-compaction to remove ground water, and so forth.

8.3.3 Structures

The structures required for small to medium-sized sawmills are minimal, particularly in tropical countries. Process equipment, electrical services, operating supplies and spare parts should be protected from rainfall. Workers should be shielded from direct sunlight and also have some protection from rain. Security is a vital aspect of any industrial operation and is probably best achieved through the provision of 24-hour surveillance by a security staff, rather than reliance upon an enclosed structure. Finally, some provision must be made for an enclosed office space to allow for the preparation and protection of operation and financial records.

In the case of portable and small sawmills in which the structures required may not involve more than a small office and lightweight rain protection, the developer can estimate the cost quite simply on the basis of local building materials and the provision of a few workers - probably including himself. For a medium-sized mill, with more substantive structures and foundation requirements, quotations can be obtained from local building contractors. Care must be taken to include all costs which may reasonably be expected to be associated with site development, including some, or all, of the following items:

i. Site purchase or lease.

ii. Transportation facilities (loading docks, log ponds, rail spurs, access roads).

iii. Sewers.

iv. Fire protection.

v. Office building.

vi. Mill stores (protection for operating supplies, maintenance materials and spare parts).

vii. Maintenance shop.

viii. Water supply.

ix. Power supply.

x. Wood handling and storage.

xi. Sawmill structures (including foundations).

xii. Sawnwood warehouse (if required).

8.3.4 Process and Ancillary Equipment

Equipment estimates are based upon the previously developed general process designs and upon estimated prices received in response to enquiries for major equipment items. This information is supplemented with quotations from local equipment suppliers, fabricators and contractors as required. All major items of process equipment must be accounted for. Suitable allowances must also be made for ancillary equipment such as materials handling. All material and equipment estimates must include the total cost delivered to the mill site. Thus, applicable surcharges covering items such as import duty, taxes, dock charges and handling, local freight and storage charges and the cost of unloading at the mill site must all be accounted for. Labour estimates for the installation of equipment must be based either on quotations received from contractors or, alternatively, on estimates by the developer of man-day requirements in conjunction with estimates of labour rates which include applicable benefits.

8.3.5 Construction Overhead

This item includes construction-related costs which would be borne directly by the developer rather than the contractor. This can include items such as temporary worker accommodation, equipment rental, owner's vehicles, temporary power, water and sewage services, and job site management.

8.3.6 Engineering

Some allowance should be made for engineering fees associated with the design and construction of the mill. In the case of large mills this cost would normally be in the order of 7 to 8 percent of the total plant capital. For a portable mill it is unlikely that any engineering fee would be encountered, as the process equipment would be supplied as a complete operating unit. Similarly, a small sawmill would probably only require minimal involvement of engineering services, particularly if the selected equipment suppliers provide comprehensive technical and installation information. In the case of a medium-sized mill, it is quite probable that the developer would wish to engage a sawmill engineer to advise on the mill design, equipment sizing and solution and to possibly provide construction supervision.

8.3.7 Working Capital

The estimates provide for capital invested in inventories of sawlogs, finished and dried sawnwood, fuel, lubricants, repair materials, saw blades and other consumable materials. Also included in the working capital are accounts receivable, pre-paid expenses and a cash reserve. The amount of current assets is partially offset by an allowance for accounts payable.

The build-up of sawnwood, sawlog and possibly other inventories would continue after start-up and would be financed either by cash from operations or by capital funds provided. The cash flow projection would indicate the availability of funds from operations.

In new business ventures it is particularly important to provide sufficient working capital to meet the costs of the first weeks or months of operations until a cash flow has been established. A subsequent rapid expansion in sales may create a need for additional working capital to meet the cash costs of production.

8.3.8 Pre-Operating Expense

Pre-operating expenses are non-construction expenditures incurred before there is an inflow of funds from operations. Included in the pre-operating expense are salaries, wages and expenses of personnel engaged at various stages before start-up, as well as insurance, property taxes, supplies and other items required in readiness for the start of operations.

The pre-operating expense is usually written off over a period of time, in accordance with allowable local practice, as defined within the appropriate income tax regulations.

8.3.9 Capitalized Interest Expense

In projects which are partially financed with borrowed funds, interest is usually calculated on the amount drawn and sometimes a commitment fee calculated on the amount not drawn is also charged. During the construction period and up to the time that cash is available to pay interest or make loan repayment instalments with interest, the amounts of interest due are added to the amount borrowed. During this period of grace, interest on interest is calculated and also added to the outstanding amount of the loan.

8.3.10 Contingencies

When estimating the plant capital cost, the estimates include the cost of all the known components in line with the engineering concept. However, as detailed design and construction proceed and more is known about the plant and processing, certain items may be required which were not included in the departmental estimates. A contingency allowance is included in the initial plant capital cost estimates to cover the cost of additional components or changes to the original concept. The amount of the contingency is a matter of judgement, but for the capital cost shown in this guide, the allowance is 10 percent of the sum of the plant capital, engineering and construction overhead. The contingency allowance is not intended to provide for the escalation of costs during the planning, design, and construction period.

8.3.11 Summary Tabulation of Capital Costs

Once the basic capital cost data havebeen developed, it should then be assembled into a simple tabular arrangement. This will organize the data and help ensure that none of the essential cost estimates have been overlooked. A suggested format follows:

Capital Cost Summary

Item	Cost $
Site acquisition and preparation	
Structural materials	
Erection	______
Total site and structures	
Imported machinery and spares, CIF entry port	
Import duties and charges	
Local handling and delivery to site	
Local manufacture and equipment, delivered to site	
Equipment installation and assembly	______
Total installed equipment	

Ancillary equipment (not included above)
Construction overhead
Engineering
Contingencies

Total plant investment

Pre-operating expense
Capitalised interest
Working capital

Total Investment

The sample format can be modified to meet specific requirements. More than one case may be included in order to compare total investment requirements. The foreign exchange component may need to be shown separately in order to meet local regulations. In some cases, the materials, equipment and labour may all be supplied by a single contractor at a fixed cost.

It is important that all supporting documents and calculations underlying the final capital cost estimate be kept on file, clearly referenced as to source and date. This greatly reduces the amount of time and effort required to up-date estimates should the project be delayed or to verify cost estimates should they be questioned by potential lenders or equity participants.

8.4 Manufacturing Cost Estimates

8.4.1 General

"Manufacturing cost" comprises all costs involved in the conversion of logs into sawnwood, ready for sale and delivery at the mill gate. It is frequently expressed as a cost per unit volume (e.g., $\$/m^3$) of sawnwood based on the volume of sawnwood produced in an operating year and all manufacturing costs incurred in that year.

The general procedure involved in preparing manufacturing cost estimates involves:

i. Establishment of the grades and production volume of sawnwood, based jointly on the requirements of the market, production capability and the availability of sawlogs.

ii. Establishment of statistical and cost data such as the recovery of sawnwood and residues, by type, from a volumetric unit of sawlog wood, electric power consumption per unit of sawnwood, and the delivered prices of raw materials and energy.

iii. Preparation of the manufacturing cost estimate. This step involves a series of calculations beginning with the annual production volume at normal operations to determine the required sawlog and energy quantities and costs and other material costs. Final steps involve the estimation of labour costs, salaries, insurance, property taxes and other administration and overhead expenses.

8.4.2 Unit Volumes

The volume of sawnwood over which the total manufacturing cost is distributed is the net volume of finished sawnwood sold at the mill gate. The implication of this is that all losses of wood occurring in the processing of logs to finished sawnwood must be allowed for in the cost components.

Examples of wood losses are:

i. Logs broken in the log yard so that the broken lengths are too short.

ii. Logs that sink in a log pond which are not recovered.

iii. Logs damaged by insect or fungal attack.

iv. Sawnwood that is not cut correctly on the headrig so that width or thickness is not to specification.

v. Sawnwood that is edged too heavily leaving good wood in the off-cuts.

vi. Incorrect trimming to length.

vii. Losses due to excessive checking, bowing and warping in the air-drying yard.

viii. Decay, brittle heart and similar defects appearing as the sawnwood is processed.

ix. Sawdust from all saw kerfs.

Losses due to saw kerfs and losses due to sawing and edging of the rounded surfaces together can amount to 40% to 50% of the volumes of the log. If other losses are added to this amount it is then not unusual to find that the volume of finished lumber sold represents only 30% to 50% of the volume of logs purchased.

The experience of local sawmills processing logs of similar characteristics may provide a rough guide as to the recovery percentage to be expected from a new mill. However, it is stressed that any values obtained in this way should be treated with caution due to wide variations in measurement and recording techniques, as well as the effects of equipment type, maintenance and operation.

8.4.3 Sawlogs

The production obtained from sawlogs is based on the recovery of finished sawnwood, both measured in the same unit of volume. For example, if the recovery of sawnwood is 50 percent and the unit of measurement is the cubic metre, then the requirement of sawlogs is 2 m^3 of solid wood under bark (ub) per m^3 of sawnwood. Should sawlogs be scaled in a unit of measurement different from that of sawnwood, the appropriate conversion factor is used to determine the requirement of sawlog wood. Care must be taken in the accounting process to ensure that the conversion factor is correctly used to determine the true cost of sawlog wood per unit of finished sawnwood.

The residue from the conversion of sawlogs to sawnwood consists mainly of off-cuts, edger trimmings, rejected wood and sawdust. Some of these by-products may be used in the mill or sold for remanufacturing pulp production or as firewood. For accounting purposes it is necessary to estimate the value of each class of by-product that is either utilized in the mill or sold. The disposal of wood residues that are neither usable in the mill or saleable is a cost element to be included in production costs.

8.4.4. Labour

A detailed labour cost estimate is prepared by listing each job in the mill, the basic pay rate for the job, the number of men required per job per shift, the number of shifts required per operating period, and calculating the basic cost of labour for the period. To that amount is added other direct labour costs, such as shift differential, overtime and other pay premiums, statutory holidays and vacation pay, and other allowances paid directly to the workers. There are other labour costs to the employer which are paid into funds as expenses incurred on behalf of the worker which may also be added to the labour cost account but are more usually charged to the mill administration and overhead accounts. Such expenses might include contributions to health and welfare funds, unemployment insurance, workmen's compensation fund, meals, protective clothing, travel to and from work, children's education allowances and other benefits. The types and value of the benefits paid directly to, or on behalf of, the workers vary considerably according to local custom or employment agreements. In many countries the cost of benefits to the worker may be equal to, or greater than, the basic salary.

8.4.5 Energy

The energy required to drive machinery and to provide light and heat is estimated in its various forms and is measured either in units per unit of production, or by the amount consumed in a period of time. Secondary statistics may have to be developed for the costing process. For example, assuming that the sawmill machinery is driven by electric power and the source of this energy is a diesel fueled turbogenerator, then to determine the cost of diesel fuel per unit of production the information required is:

kWh per m^3 of sawnwood,
Litres of diesel oil per kWh.

Similarly, heat used for drying sawnwood is expressed in heat units per unit of product and the fuel required to generate the heat is included in the statistics as a unit of fuel per unit of heat. Fuel for heating buildings is a seasonal requirement and can be calculated as an average usage per unit of sawnwood or listed as a total consumption in the period covered by the cost estimates. In the examples of capital and manufacturing costs contained in this guide, however, it has been assumed that the sawnwood is air-dried and the location of the mills are in areas which do not require space heating of buildings at any time.

8.4.6 Other Materials

Other materials consist of consumable supplies such as saws, fuel and oil for mobile equipment, lubricants, operating supplies and repair materials. The estimation of the cost of other materials is usually based on the actual experience of similar sawmills because it is impracticable to attempt to estimate the consumption cost of each item. The cost of other materials is usually based on a rate per unit of output, by department or for the mill as a whole, or the cost over a period of time.

8.4.7 Administration and Overhead

Administration and overhead include salaries and benefits of management, supervisory and office staff, workers' benefits (8.4.4), if not included in the labour cost estimate, general overheads, property taxes, insurance, and professional services such as legal and audit fees. General overhead includes communications, office supplies, licence fees and other levies, and sundry expenses.

The administration and overhead expenses are considered, in the above discussion, as a manufacturing cost. The estimator may wish to follow the alternate practice of showing this item separately as an operating expense to appear on the profit and loss statement as a deduction from gross profit.

8.4.8 Contingencies

A contingency allowance is included in the manufacturing cost estimates to cover the cost of unforeseen items. The ratio of the allowance to the total manufacturing cost is a matter of judgement, but for the examples of manufacturing costs shown in this guide the allowance is 5 percent of the total.

8.4.9 Depreciation

It is at the estimator's discretion whether depreciation is included in the manufacturing cost or treated separately. In any case, the stipulations of the national and/or local regulatory agencies must be taken into account in the treatment of depreciation expense.

8.4.10 Detailed Estimating Procedure

Analysis of the data required to obtain an "Estimated Manufacturing Cost per Cubic Metre of Finished Lumber" may be approached from the basis of log supply or market. Since log supply has been used as the basis for sawmill size selection, this will be continued in the following discussion.

i. Establish the volume of log supply per annum.

ii. Assume that finished sawnwood available for sale will be at a certain percentage of log volume (e.g. 40%).

iii. Establish the number of operating shifts per year taking into account seasonal shutdowns, vacations, local holiday customs, etc.

iv. Establish the duration of each shift as appropriate to the local area and prevailing laws and regulations; (e.g. for a shift of eight working hours, or 480 minutes, it is common practice to deduct two rest breaks of 15 minutes duration each and assume interruptions to production of about 50 minutes. This gives a net production time of 400 minutes. Meal periods are not considered part of the shift duration.)

v. Establish the complete cost of logs delivered to the log yard.

vi. Establish the annual wage or salary costs for each category of operating and non-operating personnel. Include all fringe benefits, paid vacations, paid sick leave, social programme costs, etc.

vii. Prepare a total annual wage and salary cost estimate by multiplying the individual costs determined in vi. above by the number of people in each category.

viii. Estimate the total annual cost of all other items.

ix. Compile the aggregate of all costs to determine the total expenditures for a year of operation.

x. Divide the total cost derived above by the estimated volume of finished sawnwood produced in a year of operation to obtain an estimate of the unit manufacturing cost. At this stage it is easy to test the effect of sawnwood recovery percentages by introducing several different values into the above calculation; (e.g. with high log quality and efficient sawmilling practices sawnwood recovered may approach 50% of log volume. Conversely, with low quality logs and poor sawmilling practices sawnwood recovery may approach 25% of log volume. Hence, the unit manufacturing cost in the first case will be half of that in the second case.)

xi. The average volume of log input to the sawmill per shift can be determined by dividing the log volume consumed per year by the number of shifts per year. The approximate number of logs to be moved into the mill per shift can be obtained by dividing the total log volume per shift by the estimated volume of the average log.

xii. The average volume of sawnwood produced per shift can be calculated by dividing the estimated sawnwood volume per year by the number of shifts per year. (When the sawmill is in operation this statistic provides a basis for rapid comparison of mill performance against forecast.) The average number of pieces of sawnwood to be produced per shift can be obtained by dividing the total sawnwood volume per shift by the estimated volume of the average piece of sawnwood produced.

xiii. The exercises described in items xi and xii are useful in analyzing the rates at which logs and sawnwood are expected to be processed. The study can be refined further into rates per minute by using the net shift production minutes obtained as described in item iv.

xiv. The application of standard industrial engineering techniques then permits analysis of probable low and high production rates, travel times and manpower work loads.

It must be emphasized that the most significant variables are log quality, log size range, and log species. Variations in log quality obviously affect the percentage of good sawnwood which may be recovered.

Small logs require greater production time for the same volume of finished sawnwood that could be produced from the optimum size of log for any specific sawmill. Logs larger than the headrig can handle require extra production time to cut them into quarters before reaching the headrig. If selection of log sizes is possible at the time of purchase, then it is desirable to maximize the number of logs within the preferred size range of a sawmill.

Dry, abrasive species requiring slow feed speeds reduce production rates and increase maintenance costs. If species selection is possible at time of log purchase, then it is advantageous to eliminate such less desirable species altogether.

8.4.11 Presentation of Results

In setting out the information collected by following the foregoing procedure all the assumptions upon which the work is based must be clearly stated.

The effect of variations in cost of logs delivered to the sawmill is of great importance, as is the reliability of supply over the anticipated life cycle of the sawmill.

To present an accurate picture upon which to base financial commitments, it is essential that the effects of various lumber recovery percentages be tested and tabulated to show the variations in unit manufacturing cost.

The expected revenue based on predicted sales of finished sawnwood is then used to determine excess of income over cost of producing lumber. Standard analytical techniques may then be used to test the economic soundness of the proposed sawmill.

A convenient and logical method of setting out this information is shown in Part 2 - Case Studies.

9.0 FINANCING

9.1 Time-Money Schedule

The capital funds required for a sawmill project are spent over a period of time commencing at the design development stage. The estimator should prepare an engineering and construction schedule to determine the commencement date of design development and the start-up date. The next step is to prepare a time-money schedule based on the anticipated spending of funds in time periods, for plant capital, working capital, pre-operating expense and other capital cost items.

The time-money schedule for plant capital would normally show a slow rate of spending in the early stages, from design, through site preparation and foundations construction. The period of heavy spending occurs during the purchase and installation of machinery and equipment. The rate of spending slows down during the commissioning period prior to start-up when expenditures are made primarily for adjustments and finishing. When preparing the time-money schedule, the estimator should allow for a time lag in the outflow of cash due to credit terms, and/or the hold back of a portion of payments due to contractors and others until agreed standards are satisfied. If such allowances are required then the actual outflow, if cash, will continue after the mill start-up.

The time-money schedule for working capital commences when funds are required prior to start-up for sufficient inventories of raw materials, operating supplies and other materials. Since the mill will not normally operate at the design capacity for several months, the inventory of sawlogs at start-up may be lower than the volume required for normal operations. In this instance, the inventory of sawlogs would be built up as the mill increases the through-put of logs up to its design capacity level.

It should be recognized that the sawlog inventory is the average over a given period. The supply of logs may, however, be erratic due to seasonal conditions affecting logging operations and transportation. The actual inventory of sawlogs at the mill will vary from month to month due to supply problems but the average inventory during a year should reflect the planned volume.

The inventories of sawnwood consist of sawnwood in the process of drying and the fully dried product. These inventories are built up during the first year to the most practical level for the sustained operation of the mill and the supply to its markets.

Other items which are included in the example of working capital in this guide are accounts receivable, prepaid expenses, cash reserve, and accounts payable. The time-money schedule for each of the above items is prepared and consolidated into one schedule for working capital.

The time-money schedule for pre-operating expenses is prepared in the same manner as the schedule for working capital. Certain costs such as the salary and expenses of the senior operating staff would be incurred throughout the construction period. Unskilled workers would probably be employed a few weeks before start-up; therefore their salaries and expenses would be incurred at the end of the construction period.

The time-money schedules for the plant capital, working capital and pre-operating expense are then consolidated into one schedule.

9.2 Financing Plan

The time-money schedule indicates when the capital funds are expected to be spent. The next step in the planning process is to consider the sources of funds and decide upon an anticipated financial structure for the business. The sources of funds include the cash available from the shareholder(s), borrowed cash, and government grants.

Governments may have financial assistance programmes in the form of outright cash grants or may offer low-cost loans, or may make loan guarantees that enable a business to obtain more favourable credit terms than it would obtain without such guarantees. Government financial assistance programmes should be thoroughly explored to identify possible sources of assistance.

If all of the capital funds are to be provided by the shareholder(s), or the balance if some funds are available from the Government, then the financing plan is merely the determination of the type or types of liability of the business to the shareholder(s) when the investment is made.

If a portion of the necessary capital funds is to be borrowed, then the anticipated financing plan will be based on a suitable ratio of long-term debt to equity. The desirable ratio would be that which optimizes the return of the shareholder's investment. However, there are certain constraints to consider such as the limit of debt and the ability of the business to meet debt service obligations. At this stage of the planning study an arbitrary debt:equity ratio may be set, say at 60:40, to determine the amount of capital funds to be borrowed.

The sources of capital funds are then reviewed in order to obtain the most favourable borrowing conditions. The aid programmes of the local government as well as those of governments of other countries and international financial agencies should be examined and applications made for eligibility to benefit from such aid, the amount available, and the conditions of the assistance. The international agencies mentioned above include the International Development Association (IDA), a World Bank affiliate for concessionary lending, which offers long-term repayment of an interest free loan at the cost of 3/4 of one percent to cover the Fund's administration expenses. The Asian Development Bank may consider a loan from Special Funds Account under most favourable conditions similar to that of IDA.

If capital funds from the above-mentioned sources are unavailable, or inadequate, then funds will have to be borrowed from ordinary capital resources. These resources include governments, international agencies, commercial banks and other financial institutions. A survey should be made of the most likely lenders to determine the availability of funds and the different loan conditions. At this stage of the planning process loans are not negotiated. The survey of the availability of capital funds is made in order to establish the most likely debt financing available to the project.

10.0 FINANCIAL PROJECTIONS AND ANALYSIS

10.1 General

The preparation and analysis of financial projections is a key element in the planning process of any industrial development, regardless of type or size. All those who may become directly involved in the proposed project such as equity investors and lenders of capital funds clearly have a strong interest in assessing the financial strength and expected returns relative to the probable risks involved. Similarly, government agencies responsible for dealing with financial grants, tax concession, etc., will need to be satisfied that the proposed project is financially sound.

There is a variety of financial analysis techniques employed in project planning ranging from relatively simple procedures to extremely sophisticated approaches involving computers and requiring a high degree of specialized training. For the small to medium-sized sawmill, the financial projections and analysis need only involve quite simple statements and calculations. Emphasis should be placed on understanding the implications of the analysis and relating these to the uncertainties which are inherent in any project and which should have become evident during the previous planning work.

The financial projects and analysis should include the following basic elements, each of which will be discussed briefly in subsequent paragraphs:

i. Income statement.

ii. Cash flow statement.

iii. Balance sheet.

iv. Profitability analysis.

v. Sensitivity analysis.

10.2 Income Statement

The income statement indicates the actual profit (or loss) which may be expected, based upon the various cost and revenue projections which have been developed separately. This statement should be projected for five years if possible. Ideally, for the first year of operations the statement should be prepared on a monthly basis, with annual projections for the subsequent years. The elements of various benefits and costs involved in the preparation of an income statement are as follows:

10.2.1 Net Sales Revenue

The net sales revenue is the product of sales volume of sawnwood and by-products and mill net selling prices. Sales volume is usually taken to be equal to mill production except during the initial operating period in which inventories of sawnwood are developed. The sales volume in the first six to twelve months will be much lower than normal as the mill gradually works up to its planned operating capacity. During this period a portion of the output will be directed to the establishment of a base inventory.

The mill net price is the estimated market price (as developed in the market study), less adjustments for transportation costs, insurance, commissions, duties and other levies which may apply.

10.2.2 Manufacturing Cost

The development of manufacturing cost has been dealt with previously. These costs include those which are fixed regardless of the mill's output levels and those which vary with production.

10.2.3 Gross Profit

The difference between net sales revenue and manufacturing cost is referred to as gross profit (or loss).

10.2.4 Depreciation and Amortization

Depreciation is a "non-cash" cost. Depreciation is a way of spreading the capital cost of the plant and equipment over the estimated life of the assets. It is very difficult to predict the life of operating equipment as it varies with its basic design and construction, intensity of utilization and maintenance. There are various methods of establishing depreciation cost. It is customary for the local income tax authority to have established procedures which must be followed for the purpose of computing taxable income and care must be taken to comply consistently with these regulations. For purposes of developing depreciation costs at the planning stage a straight line depreciation method is commonly used, whereby the plant and equipment is depreciated in equal amounts over an arbitrarily established life expectancy for the specific situation.

Amortization is the term used for the periodic write-off of pre-operating expenses. The applicable income tax regulations may dictate the period and/or rate at which the write-off is allowed; otherwise the rate used is at the discretion of the estimator.

10.2.5 Interest Expense

Financing the project has been discussed in an earlier section of this guide. Should the anticipated financing plan include borrowed funds, a debt repayment and interest schedule is prepared. The schedule will show the balance at the end of each time period, the amounts of principal repayments and interest in the time intervals, in accordance with the loan agreement(s). From the debt repayment and interest schedule the annual amounts of interest due are entered in the appropriate columns on the income statement projection.

10.2.6 Net Income (Loss) before Income Tax

The net income or loss is derived by deducting depreciation, amortization and interest expense from gross profit.

10.2.7 Income Tax

Corporate or income taxes are those taxes levied on the profits of the business by the various levels of government. The income tax act and all government incentive programmes should be carefully studied so that full advantage is taken of allowable deductions from income, carry forward of losses, tax holidays, investment tax credits and other incentives to invest. The estimated annual amount of corporate tax is entered on the projected income statement in the appropriate column.

10.2.8 Net Income

The net income (or loss) after income taxes is the net amount of profit before tax, less the amount of tax.

10.3 Cash Flow Statement

The projected cash flow statement is the most important tool used for analyzing capital expenditures. It reflects the actual cash inflow, outflow and balance and hence provides a vital measure of the operation's ability to meet its short-term cash obligations (such as payroll, log purchases, etc.) and of the "safety margin" in terms of cash balance on hand to meet unexpected demands. The cash flow statement is normally projected over the same period as the income statement and, in addition, covers the construction period, as designated by the first expenditure of funds directly chargeable to the project. The cash flows should be projected on a monthly basis during both construction period and at least the first twelve months of operation.

Cash flow is not equivalent to income, profits or earnings. Non-cash charges are not included; in most cases the operating cash flow is the sum of after-tax profits plus depreciation and amortization charges. Furthermore, the cash flow statement reflects the estimated timing of cash receipts and disbursements which, because of particular sales and purchase arrangements, as well as the method of accounting, may differ substantially from the income statement.

Cash flow projections comprise the following elements: cash from operations, cash from capital funds provided, cash expenditures and net cash flow.

10.3.1 Cash from Operations

As depreciation and amortization are non-cash expenses, they must be added to the net income figure in order to derive a true cash inflow from operations.

10.3.2 Cash from Capital Funds Provided

The time-money schedule and interest during construction calculations indicate the timing of capital funds. In the cash flow statement the funds provided to meet the expenditures at the required time are shown as "capital funds provided", with the amounts from differing sources clearly identified. When laying out the format for the cash flow projection, care should be taken to show short-term loans as a separate item, as this type of financing may be required early in the start-up period when revenue is low and cash obligations are relatively high.

10.3.3 Cash Expenditures

Cash expenditures include the outflow of cash for mill construction, working capital, pre-operating expense, additions to assets after start-up, and the repayment of debt. The time-money schedules and the interest during construction calculations show when the capital funds will be spent. The annual amounts, by the type of expense, are entered on the cash flow projection in the appropriate columns. The annual (or monthly) amounts of debt repayment are entered in accordance with the time-money schedule. Also, an allowance should be made for annual capital expenditures required to maintain the productive capacity of the mill. Included in this expenditure are major repairs and alterations and the replacement of major pieces of equipment in amounts greater than would normally be charged to manufacturing costs. These capital expenditures are charged to fixed assets and depreciated over an appropriate period.

10.3.4 Net Cash Flow

The net cash flow is the amount remaining after deducting cash expenditures from the total of cash from operations and capital funds provided.

10.4 Balance Sheet

The balance sheet statement represents the financial position of the proposed sawmill at a given point in time. It is usually projected on an annual basis, as of 31 December. The two major components of the balance sheet are:

i. Assets - current and long-term.

ii. Liabilities and owner's equity.

Current assets comprise the following elements: cash, accounts receivable, miscellaneous payments and inventories. Current assets are generally those items which are expected to be converted to cash within the next twelve months. Long-term assets consist of land value and the depreciated value of buildings and equipment.

Liabilities include both current and long-term obligations. Current liabilities include accounts payable, accrued wages and other expenses, estimated income taxes payable and other current liabilities such as monthly payments for fuel and electricity. Current liabilities are generally those short-term obligations which must be paid in the next twelve months. Long-term liabilities are the projected amounts of the long-term debt as of the balance sheet data.

Total owner's equity is the difference between total assets and total liabilities. Total equity less the value of capital stock is known as retained earnings.

10.5 Profitability Analysis

Various methods are available to assess the expected profitability of a proposed venture. In the case of small to medium-sized sawmills, the following are considered to be appropriate:

i. Gross return on total investment.

ii. Net return on equity investment.

iii. Interest coverage ratio.

iv. Debt service ratio.

v. Payback period.

The method of calculation and significance of each of the foregoing follows:

10.5.1 Gross Return on Total Investment

This ratio can be particularly useful in comparing projects. It provides a rough measure of a project's worth before the effects of financial and tax charges are included. It is calculated as follows:

$$\frac{\text{Net Sales Revenue - Manufacturing Cost}}{\text{Total Capital Investment}}$$

10.5.2 Net Return on Equity Investment

This is one of the most important measures of investment worth. It is expressed as the percentage of net income (profit) to total equity investment. It provides a means of assessing the proposed investment return relative to the return which the investor might expect to achieve in alternate ventures, including the relatively "risk free" option of investment in bonds.

10.5.3 Interest Coverage Ratio

This provides a measure of the venture's ability to generate sufficient funds to adequately meet interest payments on its debt obligations. It is calculated as follows:

$$\frac{\text{Gross Profit - Depreciation and Amortization}}{\text{Total Interest Charges}}$$

10.5.4 Debt Service Ratio

This is calculated by dividing gross profit by the sum of the payments for both interest and debt retirement. In general, a ratio below 200% is regarded as poor, with insufficient margin for safety.

10.5.5 Payback Period

The payback time is intended to provide an estimate of the number of years required to recover the capital invested in the proposed sawmill.

It is the ratio of the initial fixed investment over the annual cash flows for the recovery period. Thus, for example, if the initial investment is $18,000 and the annual cash flows are $4,000, $6,000, $6,000, $4,0000 respectively, in the first three years $16,000 of the original investment will be recovered, followed by $4,000 in the fourth year. Thus the payback period would be: 3 years + $\left(\frac{\$2,000}{\$4,000}\right)$ or 3½ years.

It should be noted that the payback method has one major shortcoming in that it fails to consider cash flows which occur after the payback period. Also, it does not take account of the magnitude or timing of cash flows during the payback period; it considers only the recovery period as a whole. Nevertheless, the payback method is a useful aid in providing a limited insight into the risk and liquidity of a project. In general, the shorter the payback period, the less risky the project and the greater its liquidity.

While more sophisticated methods are available (which take into account the "time value" of money), the complexities involved in their application are such that they are generally more appropriate for larger-scale investments than those considered in this manual.

10.6 Sensitivity Analysis

A most important aspect of any financial analysis is the examination of what happens to the project's earnings capacity should actual events differ from those upon which the planning estimates are based. The sensitivity of the projected financial return of a project to a decrease in selling price, an increase in construction costs, or an increase in manufacturing costs is of fundamental importance to both the potential equity holders and lenders of capital. All projects are subject to some uncertainty and any decision to proceed, or not, is suspect unless uncertainty is recognized and its potential impact assessed.

Sensitivity analysis involves a simple procedure. Different values for each of the principal variables (sales price, sales volume, manufacturing costs, and capital costs) are selected, and calculation made of the resulting return on investment. It is usually only necessary to select one or two alternate values for each variable in order to develop a reasonable insight into the sensitivity of the project's returns to changes in that variable.

The following simple example illustrates the sensitivity analysis technique:

Basic Assumptions:

Initial Equity	\$300,000
Selling Price	\$ 100/m^3
Selling Volume	4,000 m^3

Projected Results		Typical Year
Net Sales Revenue		\$400,000
Less Manufacturing Cost (at \$60/m^3)		\$240,000
Gross Profit		\$160,000
Less Depreciation and Amortization	\$50,000	
Interest Expense	\$25,000	
		\$ 75,000
Income before Income Tax		\$ 85,000
Less Income Tax (40%)		\$ 34,000
Net Income after Tax		\$ 51,000
Rate of Return on Initial Equity Investment (ROI)		17%

Variable	Return on Equity
Net Sales Revenue	
+10%	25%
-10%	9%
Manufacturing Cost	
+10%	12%
-10%	21%
Equity Investment	
+20%	14%
-20%	21%

The sensitivity analysis indicates that the example project is most sensitive to changes in Net Sales Revenue. As shown above, a change of 10% in Net Sales Revenue results in a change of approximately 50% in Return on Equity, from 17% to 25% for a 10% increase in sales revenues and from 17% to 9% for a 10% decrease in revenues. Both Manufacturing Cost and Equity Investment have significantly less effect on the rate of return on investment.

Another way of evaluating the sensitivy of a project is to calculate the break-even point. This is the production or sales volume at which revenues and expenses are equal and the business is neither making a profit nor incurring a loss. In calculating the break-even point care must be taken to separate expenses into those which are fixed, independent of the volume of production, and those which vary with production.

11.0 INVESTMENT ASSESSMENT

Having analysed the technical and financial feasibility of the sawmill as discussed in the foregoing sections of this guide, the final step is to make a judgement based on the accumulated information to decide whether or not to proceed with the project. This final step involves the judgement of the investor in assessing the estimated costs and benefits associated with the project, the adequacy of the projected rate of return in relation to other investment opportunities, and the risks in the project.

In a project requiring financing from various banks, the lending institutions will also make an assessment of the project in terms of its credit worthiness. Lenders will typically consider such elements as the extent of physical security for the loan, projected repayment ability, and the quality of management. In a large project the lenders may make an independent financial and perhaps even technical evaluation of the project in order to judge the degree of risk.

In projects of very large size which have an effect on a large area of the country, the Government may want to evaluate the costs and benefits to the country. Such other considerations as foreign exchange costs or savings, costs of additional infrastructure required for the project, and benefits of increased employment may be involved in this level of assessment of this proposed investment.

However, despite the size of the project and the degree of further analyses and evaluations done by agencies other than the original proponent, the ultimate economic success of the project will depend to a great extent on the objectivity and thoroughness applied to the preparation of the initial estimates for markets and revenues, mill design and capital costs, and process inputs and manufacturing costs.

INTRODUCTION

In Part I of this guide the basic principles and procedures involved in the development of a small sawmill enterprise have been explained as well as the methods by which the financial viability of a project can be assessed.

It is the purpose of Part II of this guide to apply the technical and financial considerations developed in Part I to case studies typical of sawmilling projects in tropical regions. Therefore, three cases have been selected to illustrate the principles and procedures based on the three types of sawmill described in Section 3.1, having capacities ranging from 5,000 to 20,000 m^3 per annum in log input.

While every effort has been made to use representative data for each of the regions selected, equipment costs and local conditions vary considerably from country to country. The cost and other data presented in the following cases should, therefore, be regarded as only illustrative of the principles and procedures discussed in this guide. The preparation of feasibility studies for sawmill projects must be based on current costs, duties, taxes, etc., applicable to the area under consideration.

CASE 1. PORTABLE SAWMILL

Small portable or mobile sawmills that can be easily moved from site to site to be close to the source of wood have a number of applications in developing regions. Among examples may be included the use of portable mills to supply the sawnwood requirements of a remote community, for utilizing trees felled along the alignment of a road or railway development through a forest area or as a first phase in an integrated agro-forestry project where a road system is being constructed and the indigenous forest is being cleared for crops and plantations.

In Case 1 the objective will be the supply of sawnwood to a local community situated in the eastern region of central India where the main forest types are Moist Peninsular Sal and South Indian Tropical Moist Deciduous. The sawmill enterprise would be organized and financed by a local businessman.

The assumptions made in preparing this case are summarized below.

1.1 Raw Material Characteristics

Density Group	Wood Density Percentage	Average Density (kg/m^3 at 12% M.C.)
Heavy Hardwoods	40	800
Medium Hardwoods	50	600
Light Hardwoods	10	450

Diameter Distribution

Top Ø Class	Percentage per Ø Class
cm	
15-20	3
20-30	35
30-40	34
40-50	15
50-60	10
60+	3

Log Lengths

Average log length	4 m
Maximum log length	6 m

1.2 Sawlog Production

The logging season in the area under consideration would be from mid-October to mid-June or approximately 190 days per year on a six-day week. Since the mill would be located near the logging area, logs would be skidded direct to the mill by draught animals or agricultural tractors. The mill would be moved every three to four months to keep skidding distances within economic range of the mill.

Log lengths would be standardized as far as possible to provide standard sawnwood lengths or multiples of these lengths. The estimated average delivered log cost would be in the order of US \$4.70/m^3 and, on the basis of an annual requirement of 5,000 m^3 and a working year of 190 days, the average volume of logs required per day would be about 27 m^3.

The inventory of logs would not normally exceed a week's input to the sawmill, on the assumption that the average daily delivery rate of 27 m^3 could be maintained.

1.3 Sawmill Production

It has been assumed that the main market for sawnwood would be the builders and furniture makers in an adjacent town, as well as the requirements of the farming community in the area.

Assuming an annual log input of 5,000 m^3 ub and an average conversion ratio of logs to sawnwood of 48 percent, the outturn of possible products is as follows:

Product	Percent	Volume (m^3/A)
House and commercial building (Roof trusses, doors, window frames and shutters, shelving, shop counters)	30	720
Heavy construction timber (15 x 15 cm to 25 x 25 cm)	26	620
Railway sleepers (Shorea robusta)	14	340
Furniture stock	30	720
	100	2,400

Every effort should be made to standardize sawnwood sizes to simplify mill production. However, some resawing would be required to meet specific demands. The production would be sold in random lengths as far as possible, but end trimming would be carried out with a power saw when necessary.

Sawnwood would be sold "green" or delivered to a wood yard in the adjacent town where it would be piled for air drying. Sawnwood to be air dried should be protected by dipping before stacking and the stacks protected by light, portable roofing, for protection from both sun and rain.

Such a wood yard might be equipped with a small circular resaw to reduce larger dimensions to meet specific orders. It is assumed that the average road distance from the mill to the town would be 50 km and that sawnwood transport would cost US $7/m^3 on a contract basis.

The annual volume of sawnwood being 2,400 m^3 and the number of working days about 190, then the average daily mill production would be in the order of 13 m^3, or approximately one load for a ten-tonne truck.

1.4 Sawmill Equipment

The type of portable sawmill envisaged for this case has been described in Section 3.0 and illustrated in Plate 1. A typical layout for such a mill is given in Figure 1.

The items of equipment required for a portable mill are summarized below.

- Circular saw headrig, saw diameter 1,200 mm with inserted teeth to cut logs up to 650 mm diameter.
- Simple but strong log carriage with three sets of knees and clamps.
- Edger with two circular saws of 500 mm diameter.
- Power saws for log yard and trimming.
- Hand and power tools including grinder for inserted teeth.
- Diesel power unit of 130 kW for headsaw and edger.
- Diesel-electric set of 2 kW for power tools, lighting, etc.

The log infeed deck would be constructed of poles laid with a slight inclination towards the log carriage to facilitate manual loading. Logs would be delivered as close as possible to the log infeed and moved into position on the deck, either manually or by draught animals.

Slabs, edgings and sawdust would be removed manually. Material suitable for firewood could be used by the mill employees and also sold for use in the neighbouring town. Wood waste not utilizable as domestic fuel should be burned at the mill site.

1.5 Site Preparation

Moving the mill to a new site would take two to three days depending on the type of mill.

Since the sawmill would be moved three to four times a year, site preparation would only entail selecting a suitable area of at least one hectare adjacent to the access road. The site should have a slope from the log storage area to the mill to facilitate the movement of logs to the infeed deck.

The heavy timbers generally used to support a portable mill are levelled on a cleared area and the mill machinery installed on the timbers and carefully levelled and aligned.

1.6 Buildings

A roof over a sawmill for protection from rain and/or sun is generally necessary and can be easily constructed with poles from the forest with a thatched roof of grasses or palm leaves. A small office building oould be constructed of wood and mounted on skids, so that it could be transported on a truck when moving to a new site.

Temporary housing constructed from materials available from the forest can be provided for the mill personnel. This type of housing and the roof over the mill can generally be provided by local villagers at contract rates.

1.7 Personnel

The supervisor of the mill operations should have had some sawmilling or closely related production experience. He would be responsible for log purchases, mill production and sales and would be assisted by two clerks capable of maintaining records and simple bookkeeping and other administrative duties, including sales of sawnwood from a central yard in the neighbouring town.

The key man in sawnwood production would be the sawyer who would also be responsible for the maintenance of equipment and saw doctoring. This man should have had adequate training and experience in the operation of small mills.

The remaining semi-skilled and unskilled employees would be trained on the job by the sawyer.

The personnel requirements are summarized in the following table:

Operating Staff

Category	No.	Rate Rs/day	Total Rs/day	Total US $/day
Skilled	1	20	20	2.28
Semi-skilled	2	15	30	3.42
Unskilled	5	10	50	5.70
			100	11.40
Overtime at 20%			20	2.28
Other benefits at 26%			31.20	3.56
Food costs	8	10	80	9.12
			231.20	26.36
Cost per year of 220 days			Rs 50,864	$5,800

Non-Operating Staff

Category	No.	Rate Rs/day	Total Rs/day	Total US $/day
Supervisory	1	30	30	3.42
Clerical	2	15	30	3.42
			60	6.84
Overtime at 20%			12	1.37
Other benefits at 26%			18.72	2.13
Food costs	3	10	30	3.42
			120.72	13.76
Cost per year of 240 days			Rs 28,973	$3,302

It is assumed that a working year would consist of 190 productive days, 15 days for change of mill location and 15 days annual maintenance.

1.8 Finance and Economics

Based on the preceding description of the portable sawmill, a series of schedules are prepared to organize the financial and economic information. These are described as follows:

1.8.1 Capital Cost

Table 1 shows a summary of the capital cost estimate for the mill. The detailed capital cost of the various mill components is listed in Table 2.

Table 1 also shows the total investment requirement which is greater than the cost of machinery and equipment, due to certain other items which must be provided for in order to begin operations. These other items include pre-operational and start-up expenses and a provision for working capital. Details of these items are shown in Table 3.

The need to provide for sufficient working capital in the initial investment requirement arises when a business is started. There will be a period of time after production starts before revenues are generated from sales of sawnwood. During this time expenses have to be paid and operating supplies and raw materials purchased. In this example it has been assumed that funds to sustain one month's operation would be provided in the initial working capital investment.

1.8.2 Sales Revenue

Based on the product lines described earlier, the sales volume, selling costs and net sales value are shown in Table 4. It is assumed that the average price of all products at the mill will be US $88.00/m^3. Based on the assumption that 50% of production will be transported to a wood yard in the nearest local community, the additional costs of this method of sale reduce the overall average net sales value to US $84.25/m^3 of total sawnwood produced.

1.8.3 Manufacturing Costs

The basic manufacturing statistics are shown in Table 5. The information presented in this table is shown in terms of the physical units of each item applicable to the operation.

Table 6 shows the unit cost of each of the items listed in Table 5. By combining the units consumed (Table 5) with the cost per unit of each item (Table 6), the annual cost of each item is determined. In this way the annual manufacturing cost of the portable sawmill operation is estimated to be US $71,500. A provision for contingencies is included in this estimate.

The manufacturing cost calculated in Table 6 is also expressed as US $29.81/m^3 of total sawnwood produced. Table 6 also shows the cost per cubic metre of each of the components of manufacturing cost. This breakdown is particularly useful in highlighting the cost items which have the largest monetary impact. In this case log purchases represent the most expensive element of manufacturing cost at US $9.79/m^3 of sawnwood. Moreover, the cost of wood represents 33% of the total manufacturing cost. This is an important factor to remember, both when evaluating the economic attractiveness of the project and later when the mill is in operation.

The second most significant cost element is the cost of diesel fuel. At US $7.63 m^3 of sawnwood the cost of fuel represents a further 26% of the total manufacturing cost.

1.8.4 Projected Financial Results

The projected income statement for ten years of operations is shown in Table 7. The information required to prepare this table has been taken from Tables 4 and 6. Although a ten-year period is shown for analysis, it is assumed that the operation would continue after the tenth year.

It will be seen that in the first year of operation production is shown at 2,400 m^3 while sales are only 2,200 m^3. The difference represents the initial inventory of sawnwood products. If the business were terminated at some time in the future, this inventory would be sold and, in the final year, sales would then exceed production.

The deduction from Gross Profit consisting of Depreciation requires comment. Depreciation is a non-cash charge to operations in each year, which is made to recognize the fact that the plant has a life greater than one year. The annual depreciation expense is a way of charging a portion of the capital cost of the plant to operations during a period which is estimated to be the useful life of the assets. In the case of the portable mill it has been assumed that the mill assets would have a useful life of ten years; therefore one tenth of the plant capital investment of US $226,600 is charged to operations each year.

In calculating Income Tax for this example it has been assumed for purposes of simplicity that the straight line depreciation expense discussed above would also apply for tax purposes. Normally this is not the case as special rules may apply to the calculation of depreciation expense for income tax purposes. Some of these more complex rules will be illustrated in Case 3.

Having determined the project's net income after taxation, as shown in Table 7, the next step in the analysis of the financial results of a proposal is to determine the projected cash flow as illustrated in Table 8.

The annual cash receipts consist of net income after taxes, plus the non-cash expense of depreciation. As shown in Table 8, the mill operations are expected to provide a cash flow of US $71,300 per year.

Since capital equipment wears out, gets damaged and requires periodic replacement in order to maintain continuity of operations, some of the cash received has to be reinvested. An amount of US $3,000 per year has been assumed in this case.

The net cash generated from operations, shown in Table 8 as US $68,300 per year, is, therefore, the annual benefit of the investment in this business.

1.8.5 Profitability Analysis

As indicated in Part I of this guide, several methods are appropriate for the analysis of small sawmill investments.

The Gross Return on Total Investment is calculated as:

$$\frac{\text{Net Sales Revenue - Manufacturing Cost}}{\text{Total Capital Investment}},$$

and from Tables 7 and 1 the figures for a typical year are:

$$\frac{\$202,200 - 71,500}{235,200} = 56\%$$

The Net Return on Equity Investment is calculated as:

$$\frac{\text{Net Profit after Taxation}}{\text{Equity Investment}}$$

Since in this case all the investment is assumed to be equity, the Net Return on Equity Investment is the same as Net Return on Total Investment, which is:

$$\frac{\$\ 48,600}{235,200} = 21\%$$

The Interest Coverage Ratio and Debit Service Ratio would not apply in this case, since there is no long-term debt on which annual interest charges must be paid.

The Payback Period in this case is calculated below. It is the number of years required to pay back the initial capital expenditure by relating the net cash generated to the original oash investment in the project. In this case the original investment of US $235,200 would be recovered as follows:

Year	Net Cash Generated (US $)	Cumulative Cash Generated (US $)
1	60,750	60,750
2	68,300	129,050
3	68,300	197,350
4	68,300	265,650

As indicated, the initial investment is recovered somewhere between Year 3 and Year 4, or more precisely in 3.6 years. In total, over ten years the project would generate net cash amounting to US $675,250 or 2.9 times the initial investment.

Project evaluation using more complex methods will be illustrated in Case 3.

1.8.6 Sensitivity Analysis

All projects are subject to varying degrees of risk because it is not possible to predict the future with certainty. In evaluating capital investments it is often useful to perform a sensitivity analysis on certain key variables in order to determine how much the profitability of the project would be affected by changes in the variables.

One of the most fundamental calculations often performed in sensitivity analysis is the determination of the break-even point. This is the production or sales volume at which expenses and revenues are equal. As illustrated in the calculation shown in Table 9, the break-even sales volume is approximately 417 m^3 of sawnwood per year. This is only 17 percent of the projected volume indicating very considerable flexibility in output.

Changes in key variables should also be evaluated. For example, it was pointed out earlier that wood represents 33 percent of the manufacturing cost. If the cost of logs were to increase by 10 percent, gross profit would decrease by approximately 3 percent. If both logs and fuel increased by 10 percent, gross profit would decline by about 5 percent.

The effects of changes in the key variables, Net Sales Revenue, Manufacturing Cost and Investment are shown in Table 10.

Table 1

Summary of Capital Cost Estimate

	Cost (US $)
Site and Structures	Nil *
Imported machinery and spares, CIF entry port	143,100
Import duties and charges	57,200
Local handling and delivery to site	300
Equipment assembly	Nil *
Total assembled equipment	200,600
Ancillary equipment	6,000
Construction overhead	Nil *
Engineering	10,000
Contingencies	10,000
Total plant investment	226,600

Total Investment Requirement

Total plant capital	226,600
Working capital	8,000
Pre-operational and start-up expenses	600
Total investment requirement	235,200

* Site, structures, equipment assembly and construction overhead not applicable to plant capital due to portable nature of mill.

Table 2

Detailed Capital Equipment Estimate

	Cost (US $)
Imported Machinery	
Mobile sawmill	65,200
Edger	24,300
Diesel power unit, 130 kW	21,700
Diesel electric generator, 2 kW	1,500
Workshop equipment and tools	2,500
Power saws (two)	1,000
	116,200
Spare parts at 10%	11,600
Shipping at 12%	15,300
Total imported machinery and spares	143,100
Import duties and charges applicable at rate of 40%	
Ancillary Equipment (assumed to be of local manufacture) Pick-up Truck	6,000

Table 3

Detailed Investment Requirement

Working Capital		**US $**
Logs	1 months supply, 526 m^3 at \$4.70/m^3	2,500
Fuel	1 months supply, 3,200 l at \$0.80/l	2,600
Lubricants	1 months supply, 40 l at \$3.20/l	130
Labour	1 months wages, \$40.12/day	800
Supplies	1 months	820
Site Preparation and Temporary Buildings, reserve for 1 set-up		150
Cash Reserve		1,000
Total Working Capital		8,000

Pre-operational and Start-up Expense

Normal mill staff for 3 weeks		600

Table 4

Projected Sales Volume and Net Sales Value

Sales Volume

Product	Volume (m^3/year)	Unit Price (US \$/m^3)	Annual Gross Sales Revenue (US \$)
Sawnwood for buildings	720	108	77,900
Heavy construction timber	620	45	27,900
Railway sleepers	340	81	27,500
Furniture stock	720	108	77,900
Totals	2,400	88.00	211,200

Selling Costs

Applies to 50% of production volume transported to local woodyard:

	Unit	Unit Cost	Annual Cost (US \$)
Transportation	US \$/m^3	7.00	8,400
Woodyard rental	US \$/year	6.00	600
Total Selling Cost			9,000

Average Net Sales Value	**US \$**	**US \$/m^3**
Annual gross sales revenue	211,200	88.00
Less: Selling costs	9,000	3.75
Net Sales Revenue	202,200	
Average Net Sales Value		84.25

Table 5

Manufacturing Statistics and Cost Estimates

Item		Unit	Amount
Sawnwood sales		m^3/year	2,400
Log purchases		m^3/year	5,000
Site preparation	- Contract labour	man-days/year	320
Temporary buildings	- Contract labour		
	- Sawmill roof	man-days/year	60
	- Housing	man-days/year	140
Transport of mill	- Contract	moves/year	4
Diesel fuel	- Mill	litres/hour	13
Lubricants		litres/day	1
Pick-up truck		km/day	100
Labour	- Mill operations	men	8
	- Supervisory and clerical	men	3
Annual Operating Period	- Mill machinery	days	190
	- Operations	days	220
	- Supervisory and clerical	days	240

Table 6

Manufacturing Cost Estimate

Item (US $)	Unit Rate (US $/$m^3$)	Unit Cost* (US $)	Annual Cost
Log purchases	4.70/m^3logs	9.79	23,500
Site preparation	1.14/man-day	0.15	370
Temporary buildings	1.14/man-day	0.10	230
Transport of mill	300/move	0.50	1,200
Diesel fuel	.80/litre	7.63	18,300
Lubricants	3.20/litre	.29	700
Pick-up truck operation	0.25/km	2.50	6,000
Labour - Operations	26.36/day	2.42	5,800
- Supervisory and clerical	13.76/day	1.38	3,300
Maintenance supplies	2.00/m^3logs	4.17	10,000
Contingencies		0.88	2,100
Total Manufacturing Cost		29.81	71,500

* Unit Cost expressed in US $/$m^3$ of sawnwood produced.

Table 7

Projected Income Statement

	Operating Year									
	1	2	3	4	5	6	7	8	9	10
Production (m^3)	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
Sales (m^3)	2,200	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
Average Mill Net Price US $/$m^3$	84.25	84.25	84.25	84.25	84.25	84.25	84.25	84.25	84.25	84.25
						(US $)				
Net Sales Revenue	185,340	202,200	202,200	202,200	202,200	202,200	202,200	202,200	202,200	202,200
Manufacturing Costs	71,500	71,500	71,500	71,500	71,500	71,500	71,500	71,500	71,500	71,500
Gross Profit	113,850	130,700	130,700	130,700	130,700	130,700	130,700	130,700	130,700	130,700
Less Depreciation*	22,700	22,700	22,700	22,700	22,700	22,700	22,700	22,700	22,700	22,300
Total Deductions	22,700	22,700	22,700	22,700	22,700	22,700	22,700	22,700	22,700	22,300
Income before Tax	91,150	108,000	108,000	108,000	108,000	108,000	108,000	108,000	108,000	108,400
Less: Income Tax at 55%	50,100	59,400	59,400	59,400	59,400	59,400	59,400	59,400	59,400	59,600
Net Profit after Taxation	41,050	48,600	48,600	48,600	48,600	48,600	48,600	48,600	48,600	48,800

*Depreciation based on straight-line, 10-year life of plant assets for both book purposes and income tax calculation.

Table 8

Projected Cash Flow Statement

	Operating Year									
	1	2	3	4	5	6	7	8	9	10
Cash Receipts										
Net Profit after Taxation	41,050	48,600	48,600	48,600	48,600	48,600	48,600	48,600	48,600	48,800
Add Non-Cash Deductions Depreciation	22,700	22,700	22,700	22,700	22,700	22,700	22,700	22,700	22,700	22,300
Cash Flow from Operations	63,750	71,300	71,300	71,300	71,300	71,300	71,300	71,300	71,300	71,100
Cash Expenditures										
Reinvestment*	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Net Cash Flow	60,750	68,300	68,300	68,300	68,300	68,300	68,300	68,300	68,300	68,100

* Periodic reinvestment in plant and equipment is required to replace worn out equipment to maintain production

Table 9

Calculation of Break-even Point

Basic Assumption:

Net Sales Revenue at Break-even point = Variable Manufacturing Costs plus fixed costs

Net Sales Revenue	=	Net Sales Value x Break-even Sales Volumes
	=	US $ 84.25 x "S"
Variable Costs	=	Manufacturing Costs x Break-even Production Volume
	=	US $ 29.81 x "S"
Fixed Costs	=	Depreciation
	=	US $ 22,700

Then

$$(84.25)S = (29.81)S + 22,700$$

$$S = \frac{22,700}{(84.25 - 29.81)} = 417 \text{ m}^3 \text{ per year}$$

Break-even Sales/Production Volume is 417 m^3 of sawnwood per year.

Table 10

Sensitivity of ROI to changes in Key Variables

Variable	Net Return on Investment*
Base case	21%
Net Sales Revenue	
+ 10%	23%
- 10%	17%
Manufacturing Cost	
+ 10%	19%
- 10%	22%
Total Investment	
+ 10%	18%
- 10%	23%

The sensitivity analysis indicates that this project is not particularly sensitive to changes in the key variables. The break-even analysis also indicated that the project had a wide range of profitability.

* Net Return on Investment = Net Income after Taxation divided by Total Investment.

CASE 2. SMALL PERMANENT MILL

The establishment of a small, permanent sawmill would be feasible where a local demand for sawnwood already exists or could be developed and a reliable supply of logs can be maintained. As in the case of the portable mill, the permanent mill might be the first stage in the development of a bigger mill in which case the initial planning and layout should provide for expansion and additions when market conditions justify such a course.

This case is based on a sawmill located close to town in the Indonesian/Malaysian region utilizing timber from Mixed Dipterocarp Hill Forests. It is assumed that the sawmill enterprise would be privately owned and operated by an experienced sawmill manager.

2.1 Raw Material Characteristics

Average Wood Density - 610 kg/m^3
Range of Wood Density - 400 - 800 kg/m^3

Diameter Distribution

Diameter Class (cm)	Percentage per Class
45 - 60	23
60 - 90	45
90 -120	27
122+	5

Log Lengths

Average log length	5 m
Maximum log length	8 m

2.2 Sawlog Production

Due to high rainfall and the generally hilly conditions in the forest, logging would be restricted to a period of 8 to 9 months from March to November-December. Sufficient logs would be stored at the sawmill at the end of the logging season to keep the mill in operation for three months. Hence, the sawmill would be in operation for eleven months each year, with annual maintenance and overhaul of the equipment being carried out during the remaining month.

Since extended log storage is necessary in this case, it is proposed that a log pond be used in order to keep log degrade to a minimum.

It is envisaged that contractors would deliver sawlogs to the sawmill in standardized lengths or in multiples thereof and that the average delivered cost would be US \$14/m^3.

2.3 Sawmill Production

The assumption in this case is that the principal markets would be retailers, builders and furniture workshops in neighbouring towns as well as the farming community.

Assuming an annual log input of 10,000 m^3 ub and an average conversion ratio of logs to sawnwood of 50 percent, the distribution of products could be as follows:

Market	Percent	Volume (m^3)
Retailers	20	1,000
Builders	50	2,500
Furniture stock	20	1,000
Agricultural construction	10	500
	100	5,000

The type of sawmill proposed in this case would be suitable for cutting flooring and siding as well as the smaller sizes required for interior trim in building construction. Typical product classes and prices are listed below:

2.4 Sales Volume

Product	Volume m^3	Unit Price US $/m^3$	Annual Gross Sales Revenue US $
Sawnwood for buildings	3,500	116	406,000
Heavy construction timber	500	56	28,000
Furniture stock	1,000	116	116,000
	5,000	110	550,000

It is assumed that 40 percent of the mill production would be air dried for six to eight weeks and the remainder sold "green".

Assuming an annual production of 5,000 m^3 of sawnwood and 240 productive days per year, the average daily production would be in the order of 21 m^3.

2.5 Sawmill Equipment

A typical layout for a small permanent mill is shown in Figure 2 and in Plate 2. A description of the mill is given in Section 3.0 of this guide and the main items of equipment required are listed below:

Item

Jack ladder
Log infeed deck
Headsaw - circular 1,500 mm ∅ + top saw 1,000 mm ∅
Log carriage
Headrig rollcase and transfer tables
Edger - manually set with 2 saws
Mountain type trimmer - 2 saws
Single swing crosscut saw
Green chain
Power saws (2)
Hand and power tools, etc.
Diesel-electric power unit - 150 kW
Pick-up truck

2.6 Mill Site Requirements

The factors to be considered in selecting a site for a sawmill are listed in 3.2.1 on page 21. It is assumed in this case study that the mill would be located close to a town since such a location facilitates building up a stable labour force and the cost of housing and amenities can generally be eliminated.

The site would be chosen to make use of topography and the natural drainage system for the construction of a log pond. This method of storage is necessary to reduce degrade of the three months supply of logs to a minimum. Since a proportion of the logs would not float, a winch would be installed alongside the jack ladder to haul them from the pond.

It is assumed that 40 percent of the mill production would be stacked for air drying for a period of about eight weeks. The stacks would be protected initially by means of portable roof units which could be replaced at a later stage by a permanent roof over the drying area. (See Section 3.6.)

The total site area required for the sawmilling project is estimated as follows:

2.7 Site Area

2.7.1 Log Pond Area

Assumptions: in pond 3,000 m^3, divided over 3 species

Average log diameter: 750 mm, log to water ratio: 75%.

Log inventory of 1 species $= \frac{3,000\ m^3}{3} = 1,000\ m^3$.

Water surface occupied by floating logs is:

$$\frac{1,000\ m^3}{4(0.750) \times 0.75} = \pm\ 2,265\ m^2.$$

Total water area required, allowing for circulation and boat ways, is from 1.25 to twice the above calculated log area. For this case, assume 1.6 as the factor.

Log pond area required for 1,000 m^3 = 1.6 x 2,265 m^2 = $\pm$ 3,625 m^2, say 3,600 m^2.

For a 3 species sort at 1,000 m^3 each a log pond will be required of approximately 3 x 3,600 m^2 = 10,800 m^2, say 11,000 m^2.

2.7.2 Air Drying Yard Area

Assumptions:
- 40% of production air dried for 8 weeks
- 60% of production air dried for 3 weeks
- 100 m^3 of logs produce 50 m^3 of lumber
- stacks contain $\pm$ 20 m^3 (SWE) of lumber (5m x 2m x 2m)
- average stack length is 5 m
- average stack density is $\pm$
- roadways of 10 m between stacks and 10 m wide roads at sides and ends.
- 3 species sort.

Lumber volume production during 8 weeks is:

$$\frac{10,000 \times 2}{48} \times \frac{50}{100} = \pm\ 833\ m^3.$$

40% of this production to be air dried for 8 weeks is

$$\frac{40}{100} \times 833\ m^3 = \pm\ 333\ m^3.$$

Assuming 3 species sort in equal quantities is:

$$\frac{333\ m^3}{3} = \pm\ 111\ m^3 \text{ per species.}$$

Stack area is:

$$\frac{111\ m^3}{2\ m \text{ height} \times 0.8 \text{ density}} = \pm\ 69\ m^2.$$

Area of air drying yard, including roadways and circulation, ranges from 5 to 7 times the stack area, on average 6 times: therefore, area required for 1 species is:

$6 \times 69\ m^2 = \pm\ 416\ m^2$, say $400\ m^2$

Area required for 3 species is $3 \times 400\ m^2 = \underline{1,200\ m^2}$.

For the portion of sawnwood requiring 3 weeks air drying, the following area is needed:

Lumber volume production during 3 weeks is:

$$\frac{10,000 \times 3}{48} \times \frac{50}{100} = \pm\ 312\ m^3.$$

60% of this production to be air dried for 3 weeks is:

$$\frac{60}{100} \times 312\ m^3 = \pm\ 188\ m^3.$$

Assuming a 3 species sort in equal quantities is:

$$\frac{188\ m^3}{3} = \pm\ 62\ m^3 \text{ per species.}$$

Stack area is:

$$\frac{62\ m^3}{2\ m \text{ height} \times 0.8 \text{ density}} = \pm\ 39\ m^2$$

Area of air drying yard is, as above, 6 times the stack area: therefore, area required for 1 species is:

$$6 \times 39\ m^2 = \pm\ 234\ m^2, \text{ say } 230\ m^2.$$

Area required for 3 species is $3 \times 230\ m^2 = 690\ m^2$, say $\underline{700\ m^2}$.

The total area required for air drying is thus:

$$1,200\ m^2 + 700\ m^2 = \pm\ 1,900\ m^2, \text{ say } \underline{2,000\ m^2}.$$

The total site area requirement for Case 2 can be summarized as follows:

a)	Log pond	11,000 m^2
	Air drying yard	2,000 m^2
	Buildings	1,200 m^2
	Unloading area, waste storage, etc.	2,000 m^2
		16,200 m^2

2.8 Buildings

It is assumed that the sawmill building would be constructed of timber with metal roofing, wood flooring and the equipment mounted on concrete foundations. Walls would only be installed where protection from heavy rain or high winds is required. The floor area of the mill is approximately 1,000 m^2.

An office and stores would be constructed of timber with a metal roof, the foundations being brick pillars capped with termite barriers to keep the structure clear of the ground. The area of this building would be about 200 m^2.

Open sheds for sawnwood drying ($\pm$ 200 m^2) could be added, for example, in the fourth year of the mill operation.

A fence around the perimeter of the site would be required to prevent unauthorized persons, cattle, etc., entering the mill area. The total length of this fence would be approximately 600 m.

2.9 Personnel

For the management of the type of sawmill considered in the present case broad experience would be required in sawmill operations, log purchasing and sawnwood marketing. The manager would have an administrative staff of three, one of whom would have sufficient bookkeeping experience to be able to maintain the mill accounts with the supervision of the manager.

Mill operations would be directed by the sawyer, and saw and mill maintenance carried out by a mechanic. Both of these men must have had adequate practical experience in their respective fields and would probably have to be brought in from more developed centres in the country. Alternatively, local men with appropriate technical skills might be sent to sawmilling training centres or to industry as soon as a decision has been reached to build a mill.

Nine men in addition to the sawyer would be required on the mill floor, two men at the log pond and a further two men to move sawnwood to the drying yard on simple rubber tyred carts and to stack it for drying. The sawyer would be responsible for the training on-the-job of the workforce.

A watchman would be necessary for the security of the plant during non-operating hours.

Any additional work required at the mill could be provided through overtime or by the employment of casual labour.

The personnel requirements are summarized in the following table:

Operating Staff

Category	No.	Rate B $/month	Total B $/month	Total US $/month
Skilled	1	853	853	461
Mechanic	1	853	853	461
Semi-skilled	3	533	1,599	863
Unskilled	11	320	3,520	1,901
			6,825	3,686
Overtime at 20%			1,365	737
Other benefits at 26%			1,774	958
Cost per month			9,964	5,381
Assuming 12 months work per annum:			B $119,568	US $64,572

Non-Operating Staff

Category	No.	Rate B $/month	Total B $/month	Total US $/month
Management	1	1,000	1,000	540
Clerical	3	426	1,278	690
Watchman	1	350	350	189
			2,628	1,419
Overtime at 20%			526	284
Other benefits at 26%			683	369
			3,837	2,072
Assuming 12 months work per annum:			B $46,044	US $24,864

N.B. It is assumed that a working year would consist of 220 days, plus 20 days for annual maintenance.

2.10 Finance and Economics

As for Case 1 a series of schedules have been prepared to organize the financial information. These are as follows:

2.10.1 Capital Cost

A summary of the capital cost estimate for the sawmill is shown in Table 1, along with the total investment requirement. The detailed capital equipment estimate is shown in Table 2.

The total investment requirement totals US $1,827,000, comprised of US $1,646,000 for the physical plant of the sawmill, US $104,000 for permanent working capital and US $77,000 for pre-operational and start-up costs.

The components of permanent working capital are summarized in Table 3, with details in Table 4. This mill has a substantial working capital requirement because of the need to stock-pile three months supply of logs during the rainy season and because of the drying time of the products. Approximately the entire mill production for one month is drying at any time.

Pre-operational and start-up expenses are shown in Table 3. These expenses assume that the full mill personnel complement would be employed for six months prior to full operation commencing. During this time the personnel would be fully trained in operation and maintenance of the facilities. It has also been assumed that for two months of the start-up period, sawnwood would be produced at 25% of capacity as part of the training for operation. All these costs have been capitalized, that is, included in the capital cost of the mill.

2.10.2 Sales Revenue

The projected sales volumes and net sales value is shown in Table 5. The net sales value of US $108.92 is slightly lower than the average gross selling price due to the 5% discount of the 1,000 m^3 per annum sold to retailers.

2.10.3 Manufacturing Costs

The basic manufacturing statistics are shown in Table 6 and the manufacturing cost estimate is shown in Table 7.

Based on the various manufacturing inputs, the unit cost to produce sawnwood is US $63.76 per cubic metre at full capacity of 5,000 m^3/A.

The largest single cost component is the cost of logs at US $28.00 per m^3 of sawnwood produced. The total labour cost of US $16.41/$m^3$ is the next major cost. Together logs and labour account for 70% of the total manufacturing cost.

2.10.4 Projected Financial Results

The information developed in the preceding tables is combined in Table 8 to create a projected income statement. Certain assumptions are reflected in this statement:

a) A mill life of 15 years for evaluation purposes but also assuming operations continue beyond year 15.

b) Production at capacity beginning in Year 1. This should be possible considering the fairly extensive start-up period discussed earlier.

c) Sales in Year 1 of 4,500 m^3 reflect accumulation of the inventory of sawnwood in the air drying stage.

d) Depreciation and amortization are taken as straight-line over 15 years.

e) Income taxes have been based on straight-line depreciation and amortization and do not reflect any provisions for accelerated depreciation or investment incentives.

The projected cash flow statement is shown in Table 9. The initial cash expenditures consisting of Plant Capital, Working Capital and Pre-operational and Start-up Expenses are shown in Year 0.

For each of the 15 operating years the cash flow from operations consists of the net income after tax, plus the non-cash charges of depreciation and amortization.

A provision has been made for reinvestment in plant facilities to maintain productive capacity. This provision amounts to approximately 2% of the original cost of equipment or US $27,000 per year. Such reinvestment is in addition to normal maintenance and covers such things as periodic replacement of motors and other installed equipment, vehicles, and major repairs or replacements of a capital nature.

2.10.5 Profitability Analysis

Table 10 includes several measures of profitability for the proposed sawmill.

The total break-even point has been calculated to be 2,856 m^3/A, or 57% of capacity. This means that revenues would equal all expenses (including depreciation and amortization) if sales were only 2,856 m^3/A. There would, of course, be no profit or any loss at this level of sales.

Considering only cash expenses, the cash break-even point has been calculated to occur at an annual sales volume of 587 m^3, or 12% of capacity. This means that sales of only 587 m^3 per year would provide sufficient cash to exactly meet annual cash expenses. It has been assumed that supervisory and clerical labour and office supplies are the only fixed annual cash expenses and that all other manufacturing costs are directly variable with sales or production volume.

The break-even point,and particularly the low cash break-even point, indicate that the mill has a fairly high degree of flexibility in regard to sales volume.

The Gross Return on Total Investment, calculated as average annual gross profit divided by total investment, is 12%. This is not a high rate of return for this type of operation. However, as discussed earlier, the return is somewhat lower than would typically prevail in projects of this sort, since no provisions for accelerated depreciation or investment incentives have been included.

The Net Return on Equity Investment, calculated as Net Income After Tax divided by Total Equity Investment, is only 2%. This is a very low return and would not normally be sufficient to interest an entrepreneur. In this case the net return on equity is low for several reasons. The absence of incentives which reduce income taxes has reduced net income. Furthermore, the project has been assumed to be financed entirely by equity funds. Were debt financing involved, the equity investment would be smaller and the return on equity would be greater.

The Cash Payback Period representing the time required for the net cash flow to equal the original investment has been calculated to be 11.9 years. If the net cash flow were greater because of Government incentives which reduce income taxes, for example, the payback period would, of course, be reduced.

Sensitivity to changes in key variables on the return on investment measured by the Gross Return on Total Investment is shown below:

Variable		Gross Return on Total Investment
Base Case Base Case		12%
Net Sales Revenue		
+ 10%		15%
- 10%		9%
Manufacturing Cost		
+ 10%		10%
- 10%		14%
Total Investment		
+ 10%		11%
- 10%		13%
Combination of:		
Net Sales Revenue	and Manufacturing Cost	
+ 10%	- 10%	17%
+ 10%	+ 10%	13%
- 10%	- 10%	11%
- 10%	+ 10%	7%

As the foregoing sensitivity analysis indicates, the elements with the greatest effect on return on investment are Net Sales Revenue and Manufacturing Cost. An increase of 10% in Net Sales Revenue could increase the return on investment to 15%. If the Net Sales Revenue could be increased by 10% at the same time as Manufacturing Cost is reduced by 10%, the return on investment would improve from 12% to 17%.

Table 1 - Summary Capital Cost Estimate

SAWMILL: 5,000 m^3/A Sawnwood Production

Description	Labour	Material (US $)	Total
Site preparation and site works			60,000
Structures	37,100	185,300	222,400
Imported machinery and equipment	123,200	843,000	966,200
Import taxes and customs charges			75,900
Ancillary equipment		8,000	8,000
Total direct cost	160,300	1,036,300	1,332,500
Construction overhead			
20% of equipment			160,200
Engineering			
4% of Total			53,300
Contingencies			
8% of Total			100,000
Total plant capital			1,646,000

TOTAL INVESTMENT REQUIREMENT

Total plant capital	1,646,000
Working capital	104,000
Pre-operational and start-up expense	77,000
Total investment requirement	1,827,000

Table 2 - Detailed Capital Equipment Estimate

Imported Materials and Equipment	Cost (US $)
Log jack ladder	10,600
Long infeed deck	10,600
Circular saw headrig	14,200
Log carriage and setworks	60,200
Edger and manual setworks	39,000
Two saw trimmer and lug chains	21,200
Swing cross cut saw	7,100
Headrig outfeed rollcase	17,700
Transfer table to edger	5,700
Edger infeed and outfeed	14,200
Transfer table to trimmer	10,600
Sorting green chain	49,600
Bad log outfeed skids	3,500
Cost holding skids	3,500
Sawdust conveyor	15,600
Diesel electric generator, 150 kW	120,400
Diesel electric generator, 15 kW	35,400
Electrical power, lighting and control wiring	177,100
Materials and equipment to be installed	616,200
Workshop equipment and tools	63,800
Power saws	4,200
	68,000
Spare parts at 10%	68,400
Shipping at 12%	90,400
Total imported machinery and equipment	843,000

Table 3 - Detailed Investment Requirement

		US $	
Working Capital			
Logs	3 months supply	38,200	
Sawnwood	average 386 m^3 air drying at any time	36,100	
Supplies and fuel	1 months supply	6,900	
Total inventories			81,200
Accounts receivable	1 months sales		45,400
Cash reserve			5,000
Total Current Assets			131,600
Accounts payable	1 month		27,600
Total Working Capital Requirement			104,000

Pre-operational and Start-up Expense

Assume personnel training for 6 months including mill operation at the equivalent of 25% capacity for 2 months during training and running-in:

Labour	6 months		44,700
Running-in and training at 25% for 2 months:			
	Logs	19,100	
	Operating expenses (excluding labour) at \$19.35/m^3 x 682 m^3 sawnwood	13,200	
			32,300
Total Pre-operational and Start-up Expense			77,000

Table 4 - Calculation of Permanent Working Capital*

Item	Quantity	Unit Value (US $/unit)	Total Value (US $)
Logs:	3 months supply		
	$= \frac{3}{11} \times 10{,}000 = 2{,}730\ m^3$	$14.00/m^3$	38,200
Sawnwood:	a) 40% dried for 8 weeks:		
	Monthly production		
	$= \frac{5{,}000}{11}\ m^3 = 454\ m^3$		
	Volume to be dried		
	$= 40\%$ of $454 = 182\ m^3$/month		
	Volume drying for 8 weeks		
	$= 182 \times 2 = 364\ m^3$	$63.76/m^3$	23,200
	b) 60% dried for 3 weeks:		
	Volume to be dried		
	$= 60\%$ of $454 \times \frac{3}{4} = 204\ m^3$		
	Volume drying for 3 weeks $= 204\ m^3$	$63.76/m^3$	13,000
Supplies and Fuel:	1 month		6,900
Accounts Receivable:	1 months sales at full capacity		
	$= \frac{5{,}000}{12}\ m^3/A = 417\ m^3$	$108.92/m^3$	45,400
Accounts Payable:	1 month at full capacity		
Logs:	$\frac{\$140{,}000/A}{9 \text{ months}} =$		15,500
Fuel:	$\frac{\$\ 35{,}300/A}{11} =$		3,200
Supplies:	(See above)		6,900
Truck	$\frac{\$\ 3{,}200}{12}$		300
Labour 1 week	$\frac{\$\ 89{,}500}{52}$		1,700
Total Accounts Payable			27,600

* See Tables 5 and 6 for details of Manufacturing Cost Estimates

Table 5 - Projected Sales Volume and Net Sales Value

SALES VOLUME

Product	Volume (m^3)	Unit Price (US $/$m^3$)	Annual Gross Sales Revenue (US $)
Sawnwood for buildings	3,500	116	406,000
Heavy construction timber	500	56	28,000
Furniture stock	1,000	116	116,000
Totals	5,000	110	550,000

SELLING COSTS

20% of the annual sawnwood production is sold to retailers at a discount of 5%. This discount is calculated as follows:

Assume that the 5% discount applies to 875 m^3 of lumber for buildings and furniture stock and to 125 m^3 of heavy construction timbers.

Discount per m^3 of sawnwood for buildings = 5% of $116 = $5.80

Discount per m^3 of heavy construction timbers = 5% of $56 = $2.80.

Total Retailer discount:

On sawnwood for builders:	875 x $5.80	=	5,075
On heavy construction timbers:	125 x $2.80	=	350
Total Discount			US $

NET SALES VALUE

	US $	US $/$m^3$
Annual gross revenue	550,000	100.00
Less: Retailer discount	5,425	1.08
Net Sales Revenue	554,574	
Average Net Sales Value		108.

Table 6 - Manufacturing Statistics and Cost Estimates

Item		Unit	Amount
Log purchases		m^3/year	10,000
Sawnwood sales		m^3/year	5,000
Fuel		litres/hour	15
Lubricants		litres/day	1
Maintenance supplies		$/$m^3$ log input	4
Pick-up truck		km/day	50
Labour	- Mill operations	men	16
	- Supervisory and clerical	men	5
Annual operating period	- Mill machinery	days	220
	- Mill maintenance	days	20
	Total Working Days		240
Average monthly production (5,000 m^3/A produced in 11 months)		m^3/month	454

Table 7 - Manufacturing Cost Estimate

Item	Unit Rate (US $)	Unit Cost* (US $/$m^3$)	Annual Cost (US $)
Log purchases	14.00/m^3 logs	28.00	140,000
Fuel	.80/litre	6.90	34,500
Lubricants	3.20/litre	.15	800
Maintenance supplies	4.00/m^3 logs	8.00	40,000
Pick-up truck	.25/km	.30	3,200
Labour - Operations	5,381/month	11.85	64,600
- Supervisory and clerical	2,072/month	4.56	24,900
Office supplies and other	400/month	.88	4,800
Contingency, 5%		3.12	15,600
Total Manufacturing Cost		63.76	328,

* Unit Cost expressed in US $ per cubic metre of sawnwood produced based on producing 5,000 m^3 in 11 months of mill operation.

Table 8 - Projected Income Statement

	Operating Year					
				4	5-14	
Production (m^3)	5,000	5,000	5,000	5,000	5,000	5,000
Sales (m^3)	4,500	5,000	5,000	5,000	5.000	5,000
Average Net Sales Value (US $/$m^3$)	108.92	108.92	108.92	108.92	108.92	108.92
Net Sales Revenue	490,100	544,600	544,600	544,600	544,600	544,600
Manufacturing Costs	328,400	328,400	328,400	328,400	328,400	328,400
Gross Profit	161,700	216,200	216,200	216,200	216,200	216,200
Less: Depreciation *	109,700	109,700	109,700	109,700	109,700	109,700
Amortization **	5,100	5,100	5,100	5,100	5,100	5,100
Income before Tax	46,900	101,400	101,400	101,400	101,400	101,400
Less: Income Tax at 45%***	21,100	45,600	45,600	45,600	45,600	45,600
Net Income after Tax	25,800	55,800	55,800	55,800	55,800	55,800

* Depreciation has been taken for both book and tax purposes on a 15-year straight-line basis.

** Amortization of pre-operational and start-up expenses has been taken over 15 years.

*** No investment incentives are included in the calculation of income taxes.

Table 9 - Projected Cash Flow Statement

	Operating Year						
	0	1	2	3	4	5-14	15
Cash Receipts							
Net Income after Tax	-	25,800	55,800	55,800	55,800	55,800	55,800
Add: Non-Cash Charges	-	114,800	114,800	114,800	114,800	114,800	114,800
Cash Flow from Operations	-	140,600	170,600	170,600	170,600	170,600	170,600
Cash Expenditures							
Plant Capital	1,646,000						
Working Capital	104,000						
Pre-operating Expense	77,000						
Reinvestment	-	27,000	27,000	27,000	27,000	27,000	27,000
Cash Expenditures	1,827,000	27,000	27,000	27,000	27,000	27,000	27,000
Net Cash Flow	(1,827,000)	113,600	143,600	143,600	143,600	143,600	143,600

Table 10 - Financial Performance Indicators

1. **BREAK-EVEN POINT**

Assume Net Sales Revenue at Break-even point equals Variable manufacturing costs plus fixed costs and that certain costs depend entirely on the volume of sales.

	Unit Cost (US $/m^3)	Annual Cost (US $)
Variable Costs:		
Logs	28.00	
Fuel and lubricants	7.05	
Maintenance supplies	8.00	
Pick-up truck	.30	
Operating labour	11.85	
Contingency	3.12	
Total Variable Costs	58.32	
Fixed Costs:		
Supervisory and clerical labour		24,900
Office supplies		4,800
Depreciation and amortization		114,800
Total Fixed Costs		144,500

Net Sales Value US $108.92/m^3

Break-even Point:

(108.92 x (Sales at Break-even) = $144,500 + (58.32) x (Sales at Break-even)

$$\text{Sales at Break-even} = \frac{\$144,500}{\$(108.92 - 58.32)/m^3} = 2,856\ m^3/A$$

or 57% of Capacity

Cash Break-even Point is the sales volume required to exactly match cash receipts and cash expenditures. Non-cash charges are deducted from Total Fixed Costs:

$$\text{Cash Break-even Point} = \frac{\$29,700}{\$50.60/m^3} = 587\ m^3/A$$

or 12% of Capacity.

2. **GROSS RETURN ON TOTAL INVESTMENT**

For a typical year, i.e. any year after Year 1, the Gross Return on Total Investment is, from Tables 8 and 9, as follows:

$$\frac{\text{Gross Profit}}{\text{Total Investment}} = \frac{\$216,200}{\$1,827,000} = 12\%$$

3. NET RETURN ON EQUITY INVESTMENT

For a typical year the Net Return on Equity Investment is as follows:

$$\frac{\text{Net Income after Tax}}{\text{Total Equity Investment}} = \frac{\$45,600}{\$1,827,000} = 2\%.$$

4. CASH PAYBACK PERIOD

Years to return the original investment of $1,827,000 from the Net Cash Flow shown in Table 9 is:

$$\$1,827,000 = \$113,600 + n \times \$143,600$$

$$n = \frac{1,827,000 - 113,600}{143,600} = 11.9 \text{ years.}$$

CASE 3. PERMANENT MILL

A permanent mill having a log input of 20,000 m^3 per annum differs from the sawmill considered in Case 2 in having a resaw which improves the productivity as well as the efficiency of the mill in cutting products such as boards and flooring.

It is assumed that the mill in this case is located in Central America and that the forest resource is classified as Humid Tropical Forest.

An independent company would be formed for the sawmill project and government financing is assumed to be available as part of a rural development scheme. The operations would be controlled by a general manager, assisted by a sawmill manager and sales manager.

3.1 Raw Material Characteristics

Wood Density

Average wood density	620 kg/m^3
Range of wood densities	400 to 1,200 kg/m^3

Diameter Distribution

Diameter Class Log top ⌀ u b (cm)	Percentage per Class (by volume)
30–39	8
40–49	22
50–59	21
60–69	15
70–79	14
80–89	8
90–99	5
100 cm +	7

Log Lengths

Average log length	6 m
Maximum log length	8 m

3.2 Sawlog Production

Because of high rainfall during the period from October to January logging operations have to be restricted to the remaining eight months of the year or 200 days.

Assuming a one month mill shutdown for maintenance, a four month inventory of logs (which includes a one month safety factor) will be required at the beginning of the rainy season. A sprinkling system will be provided for in the log yard to protect logs from degrade during storage.

The mill will be operating 11 months of the year or for 240 days per annum.

It is foreseen that logs will be delivered to the mill by contractors in standard lengths and that the average delivered cost would be US \$ 20/m^3.

3.3 Sawmill Production

It is assumed in this case that the principal markets would be retailers, builders and local furniture workshops.

Assuming an annual log input of 20,000 m^3 ub and an average conversion ratio of 60 percent, the distribution of the products could be as follows:

Market	Percent	Volume (m^3)
Retailers	30	3,600
Builders	40	4,800
Furniture stock	25	3,000
Heavy construction	5	600
		12,000 m^3

Assuming 240 production working days per annum, the daily production would be 50 m^3.

3.4 Sales Volume

Sales Volumes and Gross Revenue are summarized in the following table:

Product	Volume (m^3/A)	Unit Price (US \$/m^3)	Annual Gross Sales Revenue (US \$)
Sawnwood to retailers	3,600	126	453,600
Sawnwood to builders	4,800	126	604,800
Furniture stock	3,000	126	378,000
Heavy construction timber	600	60	36,000
Totals	12,000	122.70	1,472,400

3.5 Sawmill Equipment

A typical layout for a permanent mill of this size is shown in Figure 3. A description of the mill is given in Section 3.0 of this guide. The main items of equipment required are listed below:

- Circular saw, 1,500 mm ø + top saw of 1,000 mm ø
- Log carriage with power-setting devices
- Resaw with saw ø of 1,200 mm, with line bar and feed rolls
- Edger with two circular saws of 500 mm ø
- Two-saw trimmer with lug chains
- Overhead cross-cut saw

- Head rig rollcase with transfer tables to edger and resaw
- Resaw infeed with adjustable line bar, outfeed rollcases
- Edger infeed and outfeed rollcases
- Trim saw in- and outfeed transfer tables
- Dip tank for mechanical dipping
- Green chain
- Conveyor for waste and residual disposal
- Diesel-electric generators of 130 kW
- Workshop equipment, maintenance tools, etc.

3.6 Mill Site Requirements

The factors to be considered in selecting a site for a sawmill are described in Section 3.2.1 of this guide. In general, the same considerations apply in this case, as have been described for Case 2.

The site should be chosen in such a location where site preparation would be at a minimum for the total area required, which includes the mill and its associated structures, the log yard and the air drying yard.

In this case it is assumed that 40 percent of the mill's production will be stacked for air drying for a period of eight weeks.

A log yard of a size to store an inventory sufficient for four months' production will be required.

3.7 Buildings

The sawmill building in this case will have a floor area of 1,300 to 1,500 m^2. Its construction would be basically the same as described for Case 2.

Office spaces, stores and a workshop will have to be provided for management, sales and accounting personnel, the mechanic and the saw doctor. It would be preferable if the building housing stores and the workshop would be separate from the offices. It is estimated that the total area required is $\pm$ 300 m^2.

Open sheds for sawnwood drying could be installed at a later date, if so desired. A total area of $\pm$ 600 m^2 would be required.

In this particular case it is assumed that housing for the General Manager, the Sawmill Manager and the Sales Manager will be provided. Modest housing for these three employees would require about 300 m^2.

A fence around the perimeter of the site would be very desirable. The total length would be about 1,000 m.

3.8 Site Areas

3.8.1 Log Yard Area

Assume: 4 months log inventory of 6,660 m^3
maximum log length of 8 m
average stack height of 1.5 m
average stack density of 50%
3 log sorts to be carried out

Following a similar calculation as described in Section 3.2.2.1, and in detail for Case 2, the area calculated for stacked logs is ± 8,880 m^2 and the total area estimated for the log yard is approximately 4.5 times the stack area or ± 40,000 m^2.

3.8.2 Air Drying Yard

Assume: 40% of the mill's production is to be air dried for 8 weeks
3 species sorts to be carried out
100 m^3 of logs converts into 60 m^3 sawnwood
stacks contain ± 20 m^3
average stack length is ± 6 m
maximum stack length is ± 8 m
average stack density is ± 80%
roadways of 10 m between stacks
roads of 10 m width at sides and ends
mill operates 11 months or 48 weeks or 240 days per annum

Lumber volume production during 8 weeks is:

$$\frac{20{,}000 \times 8}{48} \times \frac{60}{100} = \pm 2{,}000 \text{ m}^3$$

40% of this production is 800 m^3

Stack area is $\frac{800}{2 \times 0.8} = 500 \text{ m}^2$

Area of air drying yard is approximately six times the stack area or

$$6 \times 500 \text{ m}^2 = 3{,}000 \text{ m}^2.$$

The total site area requirement for Case 3 can be summarized as follows:

a.	Log yard		40,000 m^2
b.	Air drying yard		3,000 m^2
c.	Buildings	- mill	1,500 m^2
		- office, stores	300 m^2
		- housing	300 m^2
d.	Unloading area, waste storage area, etc.		4,000 m^2
			49,100 m^2

3.9 Personnel

For the permanent mill of larger production capacity as described in this case, the following managerial staff has been envisaged.

The overall responsibility will rest with a General Manager.

The mill operation will be the responsibility of the Mill Manager and the Sales Manager will direct all sales operations.

The managerial staff is assisted by clerical personnel for accounting, record maintenance and sales related duties.

The personnel requirements are summarized in the following table:

Operating Staff

Category	No.	Rate Ls/A	Total Ls/A	Total US $/A
Sawyer	1	12,000	12,000	6,000
Mechanic	1	10,000	10,000	5,000
Saw doctor	1	10,000	10,000	5,000
Edgerman	1	8,000	8,000	4,000
Resaw operator	1	8,000	8,000	4,000
Trim saw operators	2	5,000	10,000	5,000
Grader	1	8,000	8,000	4,000
Unskilled	10	2,400	24,000	12,000
			90,000	45,000
Fringe benefits at 20%			18,000	9,000
Annual operating cost			108,000	54,000

Non-Operating Staff

Category	No.	Rate	Total Ls/A	Total US $/A
General Manager	1	30,000	30,000	15,000
Mill Manager	1	24,000	24,000	12,000
Sales Manager	1	24,000	24,000	12,000
Clerical Staff	4	4,000	16,000	8,000
			94,000	47,000
Fringe benefits at 20%			18,800	9,400
Annual cost, non-operating staff			112,800	56,400

It is assumed in this case that the mill operates 240 days per year of 11 months. One month has been allowed for mill and machine maintenance and overhaul.

3.10 Finance and Economics

The series of schedules prepared to preserve the financial information relative to Case 3 are somewhat more complex than those prepared for the other two cases which concerned smaller mills. The mill described in Case 3 is of a size and cost which justifies financing by a combination of entrepreneurial equity capital and government long-term debt.

3.10.1 Capital Cost

A summary of the total capital investment requirements for the mill illustrated by this case is shown in Table 1. The initial capital consists of a substantial component for working and a new component, capitalized interest, in addition to plant capital. The summarized costs are detailed in subsequent tables.

The detailed breakdown of the plant capital is given in Table 2. Each item of equipment and other elements of the total investment in physical plant are shown.

Site preparation and siteworks covers the capital required to develop the plant site, level and surface the log storage yard, and install a sprinkler system to prevent stored logs from drying and deteriorating.

Because of the relatively remote location the mill equipment includes provision for an initial inventory of spare parts of a value equivalent to 10 percent of the value of the equipment.

Ancillary equipment and facilities include two vehicles considered necessary for the operation of the mill. The two vehicles are a pick-up truck for various yard chores and local trips and a fork lift truck primarily for handling logs in the log yard and from the yard to the log infeed deck. The fork lift could also be used to handle sawnwood as required and to assist in mill maintenance.

The three overhead items comprising the plant capital are Construction or Contractor's Overhead, representing about 10 percent of the cost of materials and equipment; Engineering and Contingencies at about 8 percent of materials and equipment; and shipping from the country of origin of the equipment to the mill site. No customs or import duties are applied in this particular case.

The detailed calculations of Working Capital and Pre-operational Expense are shown in Table 3. The permanent working capital requirement represents those items of current assets and current liabilities which are expected to remain essentially at this level with the mill operating at its design capacity of 12,000 m^3 sawnwood per annum.

The major inventory item is the four months supply of logs. This large inventory, having a value of US $145,400, is required to maintain mill operations during the four month wet season when logging ceases. The other major component of working capital is one months accounts receivable, representing an average months sales of 1,000 m^3 sawnwood. The total value of inventories and accounts receivable is reduced slightly by those items which the mill would record as accounts payable for a typical month at capacity operation.

It should be noted that the permanent working capital requirement is based on full capacity operation in order to be conservative. Under actual operating conditions the working capital needs may be lower depending on production and sales volumes and the particular terms of trade. Providing for working capital in the amount calculated in Table 3 is considered prudent for a new venture of this sort, even though the operating plan reflected in the Projected Income Statement contemplates a gradual increase in production over the first two years.

The Pre-operational and Start-up Expense component of total capital investment provides for six months wages and salaries of all mill personnel and for all expenses involved in operating the mill for two months of a six month training period at a production rate equivalent to 15 percent of capacity. Such costs incurred during pre-operational training and initial mill start-up and trial operations are typically considered part of the capital cost of the mill.

The final component of the total capital investment is Capitalized Interest. This is the interest expense applicable to that portion of the total investment which is financed by long-term debt. Since the business is not yet in operation there are no available funds to actually make interest payments on debt drawn down during construction. Therefore, the interest expense for this period is added to the total amount of the loan.

The amount of interest applicable to the construction period has been derived from the Time-Money schedule shown in Table 4. In determining the applicable interest it has been assumed that equity funds could be used first. Hence, expenditures for design and procurement and for the first few months of construction could be financed by equity while later capital expenditures would be financed by debt. Interest on the outstanding amount of debt until the start of normal operations at the beginning of Operating Year 1 would comprise the total Capitalized Interest of US $117,000.

3.10.2 Sales Revenue

The Projected Sales Volume and Net Sales Value is shown in Table 5. As noted earlier, 30 percent Selling Costs in this case consist of two items. A retailer discount of 5 percent applies to the 30 percent of total sales volume sold through this means. Since 50 percent of total sales are assumed to involve transportation to customers' locations, a further deduction for shipping at the rate of US $5.00 per cubic metre shipped has been allowed. It is assumed that the balance of total sales would be picked up by customers from the mill yard.

3.10.3 Manufacturing Costs

The basic manufacturing statistics and cost estimates are given in Table 6. This information represents the consumption factors and key operating data.

The manufacturing cost estimate shown in Table 7 shows unit cost rates of the consumption factors shown in Table 6. Combining unit costs and consumption factors gives the total annual manufacturing cost at full production capacity of 12,000 m^3/A. Table 7 gives a breakdown between direct and indirect manufacturing cost for this case in which levels of management in addition to those applicable to Cases 1 and 2 are required.

At full capacity the total manufacturing cost has been estimated at US $54.76 per cubic metre of sawnwood produced.

3.10.4 Projected Financial Results

Table 8 shows the Projected Income Statement for the mill based on an evaluation period of 20 years. A 20-year life is considered a reasonable life expectancy for this mill, although it is likely that operations would continue after the 20th year.

The income statement includes two years of less than full capacity. In Year 1 it is assumed that the first six months operation would be at 25 percent of capacity, followed by 5 months at 50 percent. The 12th month has no production while the mill is shut down for maintenance. In the second year the first six months have been assumed at 75 percent of capacity, with the latter five months at 100 percent. Thereafter, for all subsequent years production at 100 percent of capacity for the normal eleven-month operating year has been assumed.

The Gross Profit figures shown in Table 8 are derived from the information in Tables 5 and 7.

Deductions from Gross Profit consist of Depreciation, Amortization and Interest Expense. Depreciation has been charged on a straight-line basis on the nominal life of wasting assets. In this case the lives assumed for depreciation purposes are:

Sawmill equipment	15 years
Structures	25 years
Site works	30 years

Because there are no particular rules in Honduras, for example, concerning depreciation for tax purposes the straight line rates described have been used for both financial record and income tax determinations.

The Amortization charge relates to the US $80,000 in pre-operational expenses which were capitalized in the total plant investment. This charge has been amortized over the first ten years of operation.

The Interest Expense applies to the long-term debt financing approximately 60 percent of the total plant investment. An interest rate of 10 percent per annum has been assumed along with loan repayment over 18 years following a two-year period of grace.

The projected income statement shown has a loss of US $164,000 which would occur in Operating Year 1 due to the low volume in the initial year. Operations would become profitable in Year 2 and would continue profitable for the balance of the 20-year evaluation period.

No income tax would, of course, be payable in Year 1. Income tax in subsequent years is at the rate of 30 percent on taxable income of less than US $500,000, and 40 percent on taxable income greater than US $500,000.

The Projected Cash Flow Statement is shown in Table 9. As in the other cases, cash flow from operations consists of net income after tax, plus the non-cash charges of depreciation and amortization. The Table indicates that a cash deficit of US $1,000 would occur in Operating Year 1, which would have to be financed by short-term borrowing. Beginning in Year 2 the cash generated from operations amounts to about US $400,000 annually.

Table 9 shown the cash expenditures necessary on an annual basis to maintain the operation.

These cash expenditures consist of an annual capital reinvestment of US $50,000 to maintain the physical plant in good operating order so its profitability can continue, and US $100,000 for debt repayment. The operation thus generates a net cash flow of approximately US $300,000 per annum.

Table 9 also shows the plant capital investment and the sources of financing.

3.10.5 Profitability Analysis

Table 10 shows some measures of profitability for this Case which were calculated for Cases 1 and 2. These include:

a) Break-even Point at 48 percent of capacity

b) Cash Break-even Point at 46 percent of capacity

c) Gross Return on Total Investment of 26 percent

d) Net Return on Equity Investment of 29 percent

e) Cash Payback Period of 4.4 years

f) Interest Coverage Ratio of 3.4 times.

These measures of profitability have been discussed in the other cases. The values applicable to this case are sufficiently favourable to suggest that the operation as conceived would have a relatively low risk of not being profitable.

To further assess the risk of the project not being profitable, the following sensitivity analysis has been made. The effect on gross return on total investment of changes in the key variables is:

Variable		Gross Return on Total Investment
Base Case		26%
Net Sales Revenue		21%
- 10%		21%
- 20%		17%
- 30%		12%
Manufacturing Cost		
+ 10%		24%
+ 20%		22%
+ 30%		20%
Total Investment		
+ 10%		24%
+ 20%		22%
+ 30%		20%
Net Sales Revenue and Manufacturing Cost:		
- 10%	+ 10%	19%
- 20%	+ 20%	12%

As shown above, if any one of the key variables changes by 10 percent in a direction which has a negative effect on Gross Profit, the Gross Return is reduced, but not below 21 percent. Manufacturing cost and total investment might have to increase by 30 percent to reduce the return to 20 percent. A 20 percent decrease in net sales revenue could cause the Gross Return to drop to 17 percent.

A combination of a 10 percent decline in net sales revenue and a simultaneous increase in manufacturing cost would drop the return to 19 percent.

Thus it may be concluded that, since quite large changes in the key variables (in the order of 20 percent) would be required to produce a substantial decrease in the gross return on total investment, the project has relatively little risk of being significantly less profitable than expected.

3.10.6 Economic Analysis

The economic assessment of the project, as distinct from the financial assessment discussed so far, is concerned with the costs and benefits of the project in relation to the economy of the region. Such factors as creation of employment, enhancement of skills, contribution to rural and regional development, provision of secondary wood products manufacturing and increase in foreign exchange earnings are considered.

In Case 3 the project involves little cost to the regional economy as it is self-sufficient in terms of required services. The benefits to the region may be significant through providing direct employment for 25, with perhaps a similar number of jobs being created in support businesses.

Other broad economic benefits of the project include the production of sawnwood for local use, and perhaps even for export, from an available resource not presently utilized. This activity adds value to the available timber and creates additional value of production in the economy. Having sawnwood available locally at reasonable cost may stimulate local construction.

The level of skills required of the mill personnel may enhance the overall skill levels in the region and may lead to the creation of other businesses or industries.

Through the reduction of any imported wood and through the possible future export of sawnwood the mill would reduce foreign exchange requirements. There will, of course, be a substantial requirement for foreign exchange to purchase the mill equipment initially.

The mill proposal, through the creation of new employment and by adding value to a natural resource, would appear to offer a significant economic benefit to the local region. Methods for estimating the monetary return of such broad economic benefits are available but a discussion of these methods is beyond the scope of this guide.

Table 1 - Summary of Capital Cost Estimate

SAWMILL: 12,000 m^3/A Sawnwood Production

Total direct capital cost	1,926,000
Engineering, overhead and shipping	400,000
Ancillary equipment and facilities	83,000
Total plant capital	2,409,000
Working capital	290,000
Pre-operational and start-up expense	80,000
Capitalized interest	117,000
Total investment requirement	

Table 2 - Detailed Capital Cost Estimate

Description	Labour	Material (US $)	Total
Site preparation and site works	18,000	70,000	88,000
Structures	84,000	334,000	418,000
Sub-Total	102,000	404,000	506,000
Sawmill Equipment			
Log infeed deck	4,000	29,000	33,000
Circular saw headrig	2,000	15,000	17,000
Log carriage and setworks	11,000	74,000	85,000
Resaw and setworks	11,000	74,000	85,000
Edger and manual setworks	8,000	56,000	64,000
Two saw trimmer and lug chains	3,000	22,000	25,000
Swing cross cut saw	1,000	8,000	9,000
Headrig outfeed rollcase	3,000	22,000	25,000
Transfer table to resaw	1,000	6,000	7,000
Transfer table to edger	1,000	6,000	7,000
Resaw infeed and outfeed	18,000	118,000	136,000
Edger infeed and outfeed	3,000	18,000	21,000
Transfer table to trimmer	2,000	11,000	13,000
Lumber dip tank	4,000	26,000	30,000
Sorting green chain	8,000	52,000	60,000
Bad log outfeed skids	1,000	3,000	4,000
Cost holding skids	1,000	3,000	4,000
Sawdust conveyor	2,000	17,000	19,000
Residual outfeed chains	1,000	7,000	8,000
Diesel electric generator (2 at 130 kW)	38,000	251,000	289,000
Electrical power, lighting and control wiring	38,000	251,000	289,000
Workshop equipment and tools	-	72,000	72,000
Power saws	-	4,000	4,000
Spare parts at 10% of equipment	-	114,000	114,000
Sub-Total	161,000	1,259,000	1,420,000

Table 2 continued

Description	Labour	Material (US $)	Total
Construction overhead	-	-	149,000
Engineering and contingencies	-	-	100,000
Shipping at 12% of equipment cost	-	-	151,000
Sub-total	-	-	400,000
Total Plant Capital	263,000	1,663,000	2,326,000
Ancillary Equipment and Facilities			
Pick-up truck	-	8,000	8,000
Fork-lift truck (with spare parts)	-	30,000	30,000
Management housing	-	-	45,000
Total Ancillary Equipment	-	38,000	

Table 3 - Working Capital and Pre-operational Expense

Working Capital (At full capacity)

Item	Quantity	Unit Value (US $/unit)	Total Value (US $)
Logs:	4 months supply =		
	$\frac{4}{11} \times 20{,}000\ m^3/A = 7{,}273\ m^3$	$20.00/m^3$ logs	145,400
Sawnwood:	40% dried for 8 weeks:		
	Volume to dry = 40% of monthly		
	production for 2 months =		
	$(.40) \times \frac{12{,}000\ m^3/A}{11\ \text{months}} \times 2 = 873\ m^3$	$54.76/m^3$	47,800
Supplies and Fuel:	1 month supplies =		
	$\frac{20{,}000\ m^3/A}{11}$ log input	$4.00/m^3$ logs	7,300
	Fuel and lubricants = $\frac{12{,}000\ m^2}{11}$	$3.78/m^3$	4,100
Total Inventories			204,600
Accounts Receivable:	1 months sales =		
	$\frac{12{,}000\ m^3/A}{12} = 1{,}000\ m^3$	$118.30/m^3$	118,300
Cash Reserve:			20,000
Total Current Assets			342,900
Accounts Payable:	Log purchases (1 months input)		36,400
	Supplies and expenses (1 month)		12,300
	Salaries and wages (2 weeks)		4,200
Total Current Liabilities			52,900
Total Working Capital			290,000

/continued

Table 3 continued

Item	Quantity	Unit Value (US $/unit)	Total Value (US $)
Training:	6 months of all personnel		55,200
Operating Trials:	2 months at 15% of capacity		
Logs	$(.15)\ \frac{(20{,}000\ m^3/A)}{11}$ (2 months) = 545 m^3	20/m^3 logs	10,900
Fuel	29 l/hour x 8 hrs/day x 40 days = 9,280 l	.80/l	7,400
Truck	50 km/day x 40 days = 2,000 km	.25/km	500
Supplies	545 m^3 log input	4/m^3 logs	2,200
Office Expenses	50% of normal		500
Contingency			3,300
Total Pre-operational and Start-up Expenses			80,000

Table 4 - Time-Money Schedule

(US $)

Activity	Duration (months)	Funds Required	Funds Provided by Debt	Funds Provided by Equity
Designs and procurement	9	359,000	-	359,000
Construction	9	2,050,000	1,297,000	753,000
Pre-operational expenses	6	80,000	80,000	-
Working capital	-	290,000	290,000	-
Capitalized interest expense	-	117,000	117,000	-
Total Initial Capital Investment	24	2,896,000	1,784,000	1,112,000

Table 5 - Projected Sales Volume and Net Sales Value

SALES VOLUME			
Product/Market	Volume (m^3/A)	Unit Price* (US \$/m^3)	Annual Gross Sales Revenue (US \$)
Sawnwood to retailers	3,600	126	453,600
Sawnwood to builders	4,800	126	604,800
Furniture stock	3,000	126	378,000
Heavy construction timber	600	60	36,000
Totals	12,000	122.70	1,472,400
SELLING COSTS			
Retailer discount, 5%	3,600	1.90	22,700
Transportation to customers (50%)	6,000	2.50	30,000
Total Selling Cost		4.40	52,700
Net Sales Value		118.30	1,419,700

* Unit price expressed as US \$/m^3 of total sawnwood sold, based on capacity of 12,000 m^3/A

Table 6 - Manufacturing Statistics and Cost Estimates

Item		Unit	Amount
Sawnwood sales		m^3/year	12,000
Log purchases		m^3/year	20,000
Diesel Fuel	- Generators	litres/hour	26
Fork-lift truck fuel		litres/hour	3
Lubricants		litres/day	2
Pick-up truck		km/day	50
Maintenance and operating supplies		US \$/m^3 logs	4
Office supplies and expenses US \$/month			500
Labour	- Mill operations	men	18
	- Office	men	4
	- Management	men	3
Annual Operating Period	- Mill	days	240
	- Maintenance	days	22
	- Office and sales	days	262

Table 7 - Manufacturing Cost Estimate

Item	Unit Rate (US $)	Unit Cost* (US $/m³)	Annual Cost (US $)
Log purchases	20/m³ logs	33.33	400,000
Diesel fuel - generators	.80/litre	3.33	39,900
Fork-lift truck fuel	.80/litre	.38	4,600
Lubricants	3.20/litre	.07	800
Pick-up truck operation	0.25/km	.28	3,300
Maintenance and operating supplies	4.00/m³ logs	6.67	80,000
Labour - Mill operations	3,000/man year	4.50	54,000
- Office	2,400/man year	.80	9,600
Contingency		1.00	12,000
Total Direct Manufacturing Cost		50.36	604,200
Indirect and Administrative Costs:			
General Manager	18,000/man year	1.50	18,000
Mill and Sales Manager	14,400/man year	2.40	28,800
Office Supplies and expenses	500/month	.50	6,000
Total Indirect Cost		4.40	52,800
Total Manufacturing Cost			657,000

*Unit Cost based on annual sawnwood production capacity of 12,000 m^3.

Table 8 - Projected Income Statement

Operating Year

Production (m^3)	4,363	10,363	12,000	12,000	12,000	12,000	12,000	12,000	12,000	
Sales (m^3)	4,145	10,145	12,000	12,000	12,000	12,000	12,000	12,000	12,000	
Net Sales Value (US $/$m^3$)	118.30	118.30	118.30	118.30	118.30	118.30	118.30	118.30	118.30	
					(US $)					
Net Sales Revenue	490,000	1,200,200	1,419,700	1,419,700	1,419,700	1,419,700	1,419,700	1,419,700	1,419,700	1
Manufacturing Costs	313,000	583,400	657,000	657,000	657,000	657,000	657,000	657,000	657,000	-
Gross Profit	177,400	616,800	762,700	762,700	762,700	762,700	762,700	762,700	762,700	
Less: Depreciation	155,000	155,000	155,000	155,000	155,000	155,000	155,000	155,000	155,000	
Amortization	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	
Interest Expense	178,400	178,400	174,200	165,000	155,000	145,000	135,000	125,000	115,000	
Income before Tax	164,000	275,400	425,500	434,700	444,700	454,700	464,700	474,700	484,700	
Less Income Tax	-	33,400	127,600	130,400	133,400	136,400	139,400	142,400	145,400	
Net Income after Tax	(164,000)	242,000	297,000	304,300	311,300	318,300	325,300	332,300	339,300	

Operating Year

11	12	13	14	15	16	17	18	19	20
,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
3.30	118.30	118.30	118.30	118.30	118.30	118.30	118.30	118.30	118.30
					(US $)				
,700	1,419,700	1,419,700	1,419,700	1,419,700	1,419,700	1,419,700	1,419,700	1,419,700	1,419,700
,000	657,000	657,000	657,000	657,000	657,000	657,000	657,000	657,000	657,000
,700	762,700	762,700	762,700	762,700	762,700	762,700	762,700	762,700	762,700
,000	155,000	155,000	155,000	155,000	18,600	18,600	18,600	18,600	18,600
,700	522,700	532,700	542,700	552,700	699,100	709,100	719,100	729,100	739,100
,100	209,100	213,100	217,100	221,100	279,600	283,600	287,600	291,600	295,600
,600	**313,600**	**319,600**	**325,600**	**331,600**	**419,500**	**425,500**	**431,500**	**437,500**	**443,500**

Table 9 - Projected Cash Flow Statement

	Development Years		Operating Year								
	1	2	1	2	3	4	5				
					(US $)						
ceipts											
ıme (Loss)			(164,000)	242,000	279,900	304,200	311,300	318,300	325,300	332,300	339,
Non-Cash Deductions											
Depreciation			155,000	155,000	155,000	155,000	155,000	155,000	155,000	155,000	155,
Amortization			8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,
ım Operations			(1,000)	405,000	442,900	467,300	474,300	481,300	488,300	495,300	502,
Funds Provided:											
Equity	610,000	502,000									
Long Term Debt	432,300	1,351,700									
ıpital Funds	1,042,300	1,853,700									
penditures											
ıpital	1,042,300	1,366,700									
rational Expense	-	80,000									
Capital	-	290,000									
ized Interest	-	117,000									
Capital			-	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50
payment			-	-	84,000	100,000	100,000	100,000	100,000	100,000	100
ısh Expenditures	1,042,300	1,853,700	-	50,000	134,000	150,000	150,000	150,000	150,000	150,000	150
h Flow	-	-	(1,000)	355,000	308,900	317,300	324,300	331,300	338,300	345,300	352

	Operating Year									
	11	12	13	14	15	16	17	18	19	20
					(US $)					
00	307,600	313,600	319,600	325,600	331,600	419,500	425,500	431,500	437,500	443,500
00	155,000	155,000	155,000	155,000	155,000	18,600	18,600	18,600	18,600	18,600
00	-	-	-	-	-	-	-	-	-	-
00	462,600	468,600	474,600	480,600	486,600	438,100	444,100	450,100	456,100	462,100
	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000		
	312,600	318,600	324,600	330,600						

Table 10 - Financial Performance Indicators

.. BREAK-EVEN POINT

Assuming Net Sales Revenue at Break-even Point equals Variable Manufacturing Costs plus Fixed Costs and that certain costs vary directly with sales volume, then:

	Unit Cost (US $/m³)	Annual Cost (US $)
Variable Costs:		
Logs	33.33	
Fuel and lubricants	3.78	
Supplies	6.67	
Pick-up truck	.28	
Operating labour	4.50	
Clerical labour	.80	
Contingency	1.00	
Total Variable Costs	50.36	
Fixed Costs:		
Management		46,800
Office supplies and expenses		6,000
Depreciation and amortization		163,000
Interest on long-term debt		174,000
Total Fixed Costs		389,800
Net Sales Value	118.30	

Break-even Point:

(118.30) x (Sales at Break-even) = 389,800 + (50.36) x (Sales at Break-even)

$$\text{Break-even Sales Level} = \frac{389{,}800}{(118.30 - 50.36)} = 5{,}737 \ m^3/A$$

or 48% of Capacity

Cash Break-even Point is the sales volume required to match cash receipts and expenditures. Non-cash charges of Depreciation and Amortization are excluded but capital reinvestment and debt repayment are included in fixed expenses.

$$\text{Cash Break-even Sales Level} = \frac{376{,}800}{(118.30 - 50.36)/m^3} = 5{,}546 \ m^3/A$$

or 46% of Capacity

2. GROSS RETURN ON TOTAL INVESTMENT

After the initial build-up years the Gross Profit remains constant for the life of the project. The Gross Return on Investment is, therefore:

$$\frac{\text{Gross Profit}}{\text{Total Investment}} = \text{US } \frac{\$\ 762,700}{\$2,896,000} = 26\%$$

3. NET RETURN ON EQUITY INVESTMENT

Although the Net Income varies over the life of the project depending on depreciation and income tax rates, a typical year could be Year 6, which has Net Income of US $318,300. The equity investment is approximately 40% of the total capital investment or US $1,112,000.

$$\text{The Net Return on Equity} = \frac{\text{Net Income after Tax}}{\text{Total Equity Investment}} = \text{US } \frac{\$\ 318,300}{\$1,112,000} = 29\%$$

4. CASH PAYBACK PERIOD

The time to return the original equity investment based on the Net Cash Flow generated by the project after repayment of long-term debt is calculated as follows:

Equity Investment: US $1,112,000

Year	Annual Net Cash Flow (US $)	Cumulative Net Cash Flow (US $)
1	(1,000)	(1,000)
2	355,000	354,000
3	308,900	662,900
4	317,300	980,200
5	324,300	1,304,500

Payout Period for Equity Investment = 4.4 years.

5. INTEREST COVERAGE RATIO

The Interest Coverage Ratio or Times Interest Earned is a measure of the mill's ability to meet the interest commitment on its long-term debt. For a typical year, say Year 3, the interest coverage ratio is:

$$\frac{\text{Earnings before Interest and Taxes}}{\text{Long-Term Debt Interest}}$$

$$= \text{US } \$ \frac{599,700}{174,200} = 3.4 \text{ times}$$

APPENDIX I

GLOSSARY AND ABBREVIATIONS

1. Glossary

Definitions in this glossary are based on those used in Lumber Manufacturing by Ed. M. Williston and in the Wood Handbook, USDA Agriculture Handbook No. 72. There are some additions and modifications to meet the needs of this guide.

AIR DRIED. Dried by exposure to air in a yard or shed without artificial heat.

ANNUAL GROWTH RING. The growth layer put on in a single growth year, including springwood and summerwood.

BAND SAW. A saw made from steel but welded into an endless belt or band with teeth on one or both edges arranged to cut sequentially.

BARK. Outer layer of a tree, comprising the inner bark, or thin inner living part and the outer bark or corky layer composed of dry, dead bark.

BARK POCKET. An opening between annual growth rings that contains bark. Bark pockets appear as dark streaks on radial surfaces and as rounded areas on tangential surfaces.

BOLT. A short section of the tree.

BOW. The distortion in a board that deviates from flatness lengthwise but not across the faces.

BOXED HEART. The term used when the pith falls entirely within the four faces of a piece of wood anywhere in its length.

CANT. See Flitch.

CIRCULAR SAW. A circular disc with teeth around the periphery.

CROOK. A distortion of a board or log in which there is a deviation edgewise from a straight line from end to end.

CROSSCUT. Cutting across the grain, e.g., a "crosscut" saw.

CUP. A distortion of a board in which there is a deviation flatwise from a straight line across the width of the board.

DECADENT. Decaying logs or timber, where 30 percent or more of the wood will not make lumber because of defect. Also called "high deduct".

DECAY. The decomposition of wood substance by fungi.

ADVANCED or TYPICAL DECAY. The older stage of decay in which destruction is readily recognized because the wood has become punky, soft and spongy, stringy, ring-shaked, pitted, or crumbly. Decided discoloration or bleaching of the rotted wood is often apparent.

INCIPIENT DECAY. The early stage of decay that has not proceeded far enough to soften or otherwise perceptibly impair the hardness of the wood.

EQUILIBRIUM MOISTURE CONTENT. The moisture content at which wood neither gains nor loses moisture when surrounded by air at a given relative humidity and temperature.

FINISH. Wood products to be used in joinery work, such as door and other fine work, required to complete a building, especially the interior.

FLITCH. A portion of a log sawn on two or more sides and intended for remanufacture into lumber. Also called "cant" or "deal", the terms being used interchangeably throughout the world.

FRAMING. Lumber used for the structural members of a building such as studs, joists, plates, sills, and so on.

GAGE or GAUGE. The thickness of the saw blade, best expressed in decimals of an inch or millimetres or "Birmingham" gauge.

GRADE. The designation of the quality of a manufactured piece of wood or of logs. A "grade" log refers to a log containing high grade lumber.

GRAIN. The direction, size, arrangement, appearance, or quality of fibres in wood or lumber. To have a specific meaning the term must be qualified.

EDGE-GRAINED LUMBER. Lumber that has been sawn so that the wide surfaces extend approximately at right angles to the annual growth rings. Lumber is considered edge-grained when the rings form an angle of 45° to 90° with the wide surface of the piece. Also called "vertical grain" or simply "V.G."

FLAT-GRAINED LUMBER. Lumber that has been sawn parallel to the pith and approximately tangential to the growth rings. Lumber is considered flat-grained when the annual growth rings make an angle of less than 45° with the surface of the piece.

STRAIGHT-GRAINED WOOD. Wood in which the fibres run parallel to the axis of the piece.

GREEN. Freshly sawn or undried wood. Wood that has become completely wet after immersion in water would not be considered green but may be said to be in the "green condition", literally not yet dried.

GUIDE or SAW GUIDE. A supporting device above and/or below the cut to restrain the saw from deviating off line. Often made of hardwood, plastic, or other materials.

HARDWOODS. Generally one of the botanical groups of trees that have broad leaves in contrast to the conifers or softwoods. The term has no actual reference to the hardness of the wood, although it is often used mistakenly to refer to "hard" wood.

HEARTWOOD. The wood extending from the pith to the sapwood, the cells of which no longer participate in the life processes of the tree. Heartwood may contain phenolic compounds, gums, resins and other materials that usually make it darker and more decay-resistant than sapwood.

HUSK. A term used for the parts of the sawing system comprising the arbor, saw, saw guide and splitter, usually on a round saw headrig.

INSERTED TOOTH. A replaceable tooth not formed from the saw body.

KERF. As used here, the width of the saw tooth where widest is generally called "net kerf" or "tooth width". The gross or total kerf is the width of wood removed by the tooth while cutting. This is usually wider than the net kerf because of wobble, flutter, tooth misalignment, variation in tooth width, bent teeth, saw blade irregularities, etc.

KNOT. The portion of a branch or limb which has been surrounded by subsequent growth of the stem. The shape of the knot as it appears on a cut surface depends on the angle of the cut relative to the long axis of the knot. Knots may be of many types. Some are tight or red knots, loose or black knots, spike knots, round knots, star or checked knots, incased knots, cluster knots, etc.

LOG. A section of the trunk of a tree in suitable length for sawing into commercial lumber. Long logs are "tree length" or so long as to require bucking or cross-cutting; short logs are ready for sawing; stud logs are 8 feet (2.44 m) long; plus trim allowance.

LONGITUDINAL. Generally parallel to the direction of the wood fibres, log length or lumber length, or simply lengthwise or endwise.

LUMBER. The product of the saw and planing mill not further manufactured than by either sawing, resawing, passing lengthwise through a standard planing machine, crosscutting to length, and matching. Finished lumber is completed, manufactured ready to ship, as opposed to "finish" lumber.

BOARDS. Lumber that is nominally less than 2 inches thick and 2 inches or more wide. Boards less than 6 inches wide are sometimes called "strips", e.g., 4-inch strips, 3-inch strips, etc.

DIMENSION. Lumber with a nominal thickness of from 2 inches up to, but not including, 5 inches, and a nominal width of 2 inches or more.

DRESSED SIZE. The dimensions of lumber after being surfaced with a planing machine. The dressed size is usually ½ to 3/4 inches less than the nominal or rough size. A 2 by 4-inch stud, for example, actually measures about 1½ by 3½ inches. Also called "net size" as opposed to rough size.

FACTORY AND SHOP LUMBER. Lumber intended to be cut up for use in further manufacture. It is graded on the basis of the percentage of the surface area that will produce a limited number of cuttings of specified minimum size and quality. This is the case mainly in hardwoods but not necessarily in softwoods.

FINISH LUMBER. High or upper grade as opposed to common or lower grades.

MILLWORK. Planed and patterned lumber for finish work in buildings, including such items as sash, doors, cornices, panelwork and other items of interior or exterior trim. Does not include flooring, ceiling or siding.

PATTERNED LUMBER. Lumber that is shaped to a pattern or to a moulded form in addition to being dressed, matched, or shiplapped, or any combination of these workings.

ROUGH LUMBER. Lumber which has not been dressed (surfaced) but which has been sawn, edged, and trimmed.

STRUCTURAL LUMBER. Lumber that is intended for use where working stresses are present. The grading of structural lumber is based on the strength of the piece as related to anticipated uses.

SURFACED LUMBER. Lumber that is dressed by running it through a planer.

TIMBERS. Lumber that is nominally 5 inches or more in least dimension. Timbers may be used as beams, stringers, posts, caps, sills, girders, purlins, etc.

YARD LUMBER. A term for lumber of all sizes and patterns that is intended for general building purposes, having no design property requirements. General lumber found in a lumber yard without assigned design values.

MOISTURE CONTENT. The amount of water contained in the wood, usually expressed as a percentage of the weight of the wood.

NOMINAL SIZE. As applied to timber or lumber, the size by which it is known and sold in the market; often differs from the actual size.

PITH. The small, soft core occurring in the structural centre of a tree trunk, branch, twig, or log.

RADIAL. Coincident with a radius from the axis of the tree or log to the circumference. A radial section of a lengthwise section in a plane that passes through the centre-line of the tree trunk.

RIPPING. Sawing or cutting with the grain as with a rip saw. When ripping is done on a planer it is usually called splitting.

SAW-DOCTORING or FILING. The maintenance work that is essential to keep saws cutting at maximum efficiency.

SAWNWOOD. See Lumber.

SEASONING. Removing moisture from green wood to improve its serviceability.

AIR DRIED. Dried by exposure to air in a yard or shed, without artificial heat.

KILN DRIED. Dried in a kiln with the use of artificial heat.

SHAKE or RING SHAKE. A separation along the grain, the greater part of which occurs between the rings of annual growth. Usually considered to have occurred in the standing tree or during felling. Shakey wood contains shake.

SINKER. A log too heavy to float in water.

SOFTWOODS. Generally one of the botanical groups of trees that, in most cases, have needlelike or scalelike leaves; the conifers; also the wood produced by such trees. The term has no reference to the actual hardness of the wood, although it is often used in that manner mistakenly for "soft" wood.

SOLID TOOTH. A saw tooth that is formed from and is an integral part of the saw blade itself.

SPECIFIC GRAVITY. The ratio of the weight of a body to the weight of an equal volume of water at 4°C, or other specified temperature.

SPLIT. A lengthwise separation of the wood, due to the tearing apart of the wood cells.

SPLITTER. A shearing device consisting of a disc or knife blade mounted behind the saw to prevent boards from falling on to the saw, or those with spring from binding or pinching the saw. When used behind circle saws, they should have a curvature corresponding to that of the saw and are mounted on the husk within 0.50 to 0.75 inches (12.7 to 19.05 mm) of the saw blade. They are wedge-shaped with the back edge being about 0.031 inches (0.787 mm) thicker than the leading edge. Also called a "shear".

SPRING. Commonly used in industry to designate locked-in tension in a log or cant released during sawing, causing the piece to deviate from a straight line.

SPRING SET. Alternately bending saw teeth to make the kerf wider than the blade.

SPRINGWOOD. The portion of the annual growth ring that is formed during the early part of the season's growth. It is usually less dense and weaker mechanically than summerwood.

STAIN. A discoloration in wood that may be caused by such diverse agencies as micro-organisms, metal, or chemicals. The term also applies to materials used to impart colour to wood.

BLUE STAIN. A blue, grey, green, or black discoloration of the sapwood caused by the growth of certain dark-coloured fungi on the surface and in the interior of the wood; made possible by the same conditions that favour the growth of other fungi; may range in colour from blue to black or dark green.

BROWN STAIN. A rich brown to deep chocolate brown discoloration of the sapwood of some pines caused by a fungus that acts much like the blue stain fungi.

CHEMICAL BROWN STAIN. A chemical discoloration of wood which sometimes occurs during the air drying or kiln drying of several species, apparently caused by the concentration and modification of extractives.

SAP STAIN. See Blue Stain.

STICKERS. Strips or boards used to separate the layers of lumber in a pile and thus permit air to circulate between the layers. Also called "sticks" or "kiln sticks".

STRUCTURAL TIMBERS. Pieces of wood of relatively large size, the strength of which is the controlling element in their selection and use. Trestle timbers (stringers, caps, posts, sills, bracing, bridge ties, guard rails); car timbers (car framing, including upper framing, car sills); framing for building (posts, sills, girders); ship timber (ship timbers, ship decking); and crossarms for poles are examples of structural timbers.

STUD. One of a series of wood structural members used as supporting elements in walls and partitions. Most often nominal 2 x 4, 2 x 6, or 2 x 8, the common stud usually being 2 x 4.

SUMMERWOOD. The portion of the annual ring that develops largely during the latter part of the season's growth, but not necessarily in the summer. It is less porous and is usually harder and heavier than springwood. Also called "latewood".

SWAGE or SWEDGE. A method of shaping a saw tooth to provide side clearance on both sides of each tooth.

SWEEP. Deviation from a straight line lengthwise.

TANGENTIAL. Strictly, coincident with a tangent at the circumference of a tree or log, or parallel to such a tangent. In practice, however, it often means roughly coincident with a growth ring.

2. Abbreviations

A	annum, year.
cm	centimetre
dbh	diameter breast height - diameter of a standing tree at 1.3 m above ground level.
ha	hectare
m	metre
m^2	square metre
m^3	cubic metre
m^3/A	cubic metres/annum
m^3/ha	cubic metres/hectare
mm	millimetre
%	percent
ob	overbark
SWE	solid wood equivalent.

APPENDIX II

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2. Planning forest roads and harvesting systems, 1977 (E* F* S*)
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