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A TECHNO-ECONOMIC STUDY OF SAW MILLING INDUSTRY IN KERALA

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Abstract

Sawmilling is a primary wood processing industry before wood is put into use in different solid wood products. An attempt is made in this study to examine the economic and technological aspects of the sawmilling industry in Kerala, in the context of declining raw material supply. The study is based on primary data collected from a sample of 165 sawmills, randomly selected from eight districts in the state.

Sawmilling in Kerala is very individualistic industry, made up of enterprising individuals. In the early years, most of the sawmills were under proprietorship. However, with the increase of capital requirements, this has been replaced with partnership form of ownership in majority of tho sawmills in the state.

A typical sawmill in Kerala has a vertical or horizontal band headrig, circular or band resaw, occasionally a trimmer/crosscut saw and a grinder. The number of these machines may be more than one in medium-size sawmills while small units may function even with single resaw. Most of the units have Indian made machineries with technical specifications of Belgium machines. The major limiting factors identified in lumber recovery are: log degradation (due to biological organisms and physical agents), availability of relatively small diameter logs, improper selection of tools and equipment and sawing patterns.

Productive capital consists of fixed capital and working capital and the latter constitutes about 72% of the productive capital. Stock of raw material is the major component of the

working capital, accounting for 66%. There exists a positive relationship between size and different types of capital and the same relationship is observed between size and income and profit.

House compounds and import are two major sources of supply of timber. Because of the shortage of raw material, the capacity utilisation is of the order of 53%. As size increases the capacity utilisation also increases, since large size mi1 is have better stock of raw material. The average outturn in a sawmill accounts for only 50%. In the context of continuous shortage of raw material, higher rate of outturn is imperative for augmenting the supply of sawn wood. This could be achieved in two ways: (1) modernisation of the sawmill and (2) protecting the logs from cracking, end splitting and biological degradation. The existing system of custom sawing is one of the constraints for the improvement of log storage technology as sawmill owner passes the loss arising out of improper storage to the customer. The necessary finance for modernisation may be mobilised either by ploughing back a part of the profit to the industry or by changing the ownership pattern. With a view to increasing the capacity utilisation and minimising the waste, integration of sawmill with other allied activities such as furniture making, joinery, etc. must be strengthened. However, formulation and effective implementation of long term forestry strategy for augmenting the supply of timber are essential to ease the raw material situation in the industry.

A Techno-Economic Study of Sawmilling Industry in Kerala

1, Background

Sawmilling refers to the conversion of logs into sawn sizes. The sawmilling industry which processes about 70% of the total industrial round wood available in the state, plays a vital role in the economy of Kerala (Muraleedharan et al. 1984). Most of the sawmills in Kerala have come up in response to the availability ot timber trom clear-telling forests carried out in different parts of Kerala. Till 1980 wood supply was quite adequate to meet the requirements of the sawmills in thestate. Due to the dwindling resources of timber and consequent to imposed han on clear-felling, decline in the supply of timber has become a major problem and in certain areas sawmilling units are being closed. Since, most of the units have come up during the period of abundant timber supply, little attention has been paid to enhance wood recovery. With the decline in supply of timber, there is an urgent need to increase the conversion efficiency in sawmilling in order to enhance the outturn. Although, this is one of the important wood based industries in the state, no detailed study has so far been carried out on the economic and technological aspects of sawmilling and therefore any information hardly exists on these two aspects of this industry. The present study focusses on the economic and technological aspects of the sawmilling industry in Kerala, especially in the context of dec1ining raw material supply.

2. Objectives

The objectives of tho study are:

i. To examine the structure and working of sawmilling industry in Kerala with particular reference to its linkages with wood production and and uses.

ii. To study the technological aspects of processing and the response of the industry to the decline in availability of timber.

3. Methodology

The study is mainly based on data collected from a sample of sawmills. Primary data, wherever necessary are supplemented by data gathered from secondary sources such as, Directorate of Bureau of Economics and Statistics, State Planning Board, Factory Inspectorate, etc.

3.1 Design of the Survey

The required frame for drawing sample was not readily available from one source. Factory Inspectorate maintains a list of sawmills which are registered and licenced under Factories Act 1948 and rules from thereunder. Since this Act precludes establishments employing less than 10 workers and using power from its purview, the information on other small sawmills is not available. Based on returns submitted by the sawmills, the Directorate of Bureau of Economics and Statistics has prepared a list, giving number of sawmills in the state. But this information is also insufficient as this does not account for non-submitting units and also does not provide names of the saw mills. The third source is Small Industries Service Institute which provides both names and number of sawmills in different districts. But scrutiny shows that some of the large units have been deleted from the list. Thus, the above three sources were used to prepare sampling frame. Till 1955, the sawmilling activity was concentrated in three districts in the state viz. Calicut, Ernakulam and Trichur. With the inauguration of second five year plan which provided more emphasis on tho development of industry, a number of sawmills have been started in other districts also. Now the sawmills are distributed in all the districts of the state, the number ranging from 7 in Idukki to 270 in Ernakulam. Of the total 1402 registered sawmills in the state, about 90% is distributed in 8 districts such as Ernakulam, Trichur, Calicut, Cannanore, Palghat, Malappuram, Kottayam and Quilon and the first three account for about 45%. Samples were drawn randomly from the above 8 districts. Of the total 165 samples, about 70% was drawn from the three traditional centres of sawmilling viz. Calicut, Trichur and Ernakulam. The information was collected by visiting each selected unit, ,during the period from April 1985 to March 1986. Information on the system of timber supply, marketing of sawn goods, etc. was also gathered from timber merchants. Details on timber extraction were ascertained through discussion with forest officers.

32 Nature of Information collected

i) Name and address of the factory and general information relating to

a) location

b) accessibility

c) year of establishment

d) year of initial production

ii) ownership

iii) type of management

iv) details of capital - fixed capital, and working capital

v) installed capacity

vi) cost of production

vii) marketing

viii) use of products

ix) employment

x) working condition of labour

xi) source of supply of timber

xii) technological aspects - log storage, log handling, gebarking, to size, primary end secondary conversion, maintenance and saw doctoring.

The selected sawmills, on the basis of maximum production capacity, are categorised into two size groups: small and medium. The sawmills with maximum production capacity less than 1500 m^3 per year and more than 1500 m^3 per year are termed as small and medium respectively. The analysis has been carried out separately for two size groups.

4. Sawmilling industry in Kerala

The origin of sawmilling in Xerala could be traced back to many centuries when timber was sawn manually for construction work and making agricultural implements. With the population increase and betterment of living condition of the people, sawn wood has been put to a variety of uses which resulted in increased demand for sawn wood and eventually led to the mechanisation in sawmi11ing sector. The first sawmi11 in Kerala was reported to be built at Beypore near Calicut by an European[1], aiming to supply sawn wood to a British Company functioned in Bombay. However this did not survive for long. The organised attempt to start a sawmill in Kerala was made only at the close of 19th century and to a great extent, was the outcome of timber trade in Malabar. Although timber trade in Malabar has a long history, the business was flourished since the beginning

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[1] This information is collected from the Archives at Calicut.

of the second half of the 19th century. From the beginning, timber trade in Malabar had concentrated on the banks of river Kallayi in Calicut city. The location of Kallayi is pre-eminently beneficial to this trade as water, rail, and road transport facilities are easily available. Originating from the midland of Calicut taluk, Kallayi river is connected with Beypore river by an artificial canal. Beypore river which tapped timber from Nilambur and adjacent hills, floated down at Kallayi where the timber was stored until it was sold. The first organised sawmill in Kerala was set up at Kallayi in 1893 by A. Brown (K.M. 1893). Because of transportation facilities availability of timber and high demand for sawn wood from Bombay and Madras, this trade at Kallayi flourished. Lured by the success, a couple of units were set up within a few years.

4.1 Growth

The growth pattern of the industry in thc state over a period of time cannot be depicted hers because of the paucity of data. However, the available data on number of sawmills in some selected centres of sawmilling indicate that the growth of industry had been slow but steady till 1960 and thereafter, it was very rapid. In Calicut, for instance, there were only 3 sawmills in 1905 which increased to 44 in 1962 and to 166 in 1984 (Sreedhara Menon 1962a). Similarly in Ernakularn between 1962 and 1984 the number of mills increased from 22 to 270, (Sreedhara Menon 1965). The same is the case in Trichur where the number of sawmills increased from 1 in 1905 to 17 in 1962 to 182 in 1584

(Srecdhara Menon 1962b). Tho rapid growth of sawmills since 1960 was attributed to a number of factors among which the most important are given below:

i. Timber was available in plenty as a result of large scale clear-felling of natural forests for plantation programme which has been carried out since 1960. Added to this, massive deforestation in the private forests in erstwhile Malabar prior to its nationalisation in 1971 increased tho supply of timber.

ii. The growing awareness of industrialisation created by the second five year plan and various incentives offered to the industrial sectors by the government resulted in starting of new industrial units in Kerala.

4.2 Number of units

Based on returns submitted by the mills, Directorate of Bureau of Economics and Statistics, has estimated total number of sawmills in the state for different years and the details of which are furnished in Table

Table 1

District-wise distribution of registered sawmills in Kerala

Districts	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Trivandrum	8	14	15	17	21	27	31	37	53	57
Quilon	80	72	79	79	97	93	95	100	106	98
Pathanamthitta	-	-	-	-	-	-	-	-	-	7
Alleppey	29	34	39	41	43	42	58	60	63	68
Kottayam	45	54	60	60	69	67	73	88	101	112
Idukki	2	3	-	1	1	4	b	b	7	7
Ernakulam	129	143	185	207	232	231	271	268	270	285
Trichur	105	119	117	130	131	132	159	174	182	182
Palghat	83	100	113	117	130	124	152	168	173	194
Malappuram	31	32	44	44	62	110	125	133	142	k45
Calicut	102	118	120	126	131	130	152	155	166	177
Cannanore	75	88	86	98	107	111	129	134	130	142
Wynad	-	-	-	-	-	-	-	6	9	8
State	689	777	858	920	1024	1071	1251	1324	1402	1482

Data presented above show only a partial picture with regard to total number of sawmills in Kerala, as it has excluded the partially working mills which have not submitted the annual returns to the government. The number of nonsubmitting sawmills in the state was as high as 730 in 1982 and 659 in 1983[2]. Thus it is presumed that the total number of sawmills in Kerala which includes both working and partialy working units falls between 1800 and 2000.

Although there are sawmills in all the districts, highest concentration is found in Ernakulam (20%, followed by Trichur (13%), Palghat (12.13%) and Calicut (11.80%)3. There are a number of reasons for high concentration of sawmills in these four districts, but probably the most important are easy availability of raw material, cheap transportation facilities and rapid urbanisation.

4.3 Employment

Table 2 furnishes the data on district-wise distribution of workers directly employed in working sawmills in the state. At the state level, this is estimated to be 8309 (see Table 2).

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2 This is based on information gathered from Directorate of Bureau of Economics and Statistics, Trivandrum.

3 Many sawmills in Kallayi are partially working and some being closed down. Probably, this may be the reason for low concentration of sawmills in Calicut.

Among different districts, Ernakulam provides employment to highest number of workers as much as 1644 persons, accounting for 20.4 percent and is followed by Calicut and Cannanore which account for 17% and 14% respectively.

Table 2

District-wise distribution of workers in registered sawmills In Kerala

District	1978	1979	1980	1984	1465
Trivandrum	89	97	126	344	338
Quilon	448	445	558	517	499
Pathanamthitta	-	-	-	-	27
Alleppey	175	181	194	265	246
Kottayam	335	321	366	524	584
Idukki	-	1	2	31	26
Ernakulam	1287	1358	1486	1644	1741
Trichur	710	818	758	956	441
Palghat	563	547	613	698	793
Malappuram	264	248	348	726	735
Calicut	1416	1349	1440	1438	1436
Cannanore	965	1020	1078	1116	1178
Wynad	-	-	-	50	57
State	6252	6365	6971	8309	860l

4.4 Systems of sawina

There are three systems of sawing prevailing in Kerala: (1) Open Conversion (2) Contract System and (3) Custom or Cooli System.

4.4.1 Open Conversion

This is one of the important system of sawing prevailing in majority of the countries in the world. under this system, the sawmill owners purchases logs, converts them and then disposes the sawn sizes. In Kerala this, system is mainly practised in certain mills in Kallayi and Balipattam.

4.4.2 Contract system

Under contract system, a contract will be drawn between merchants and sawmill owners in which terms and condition of the sawing - type and quantity of sawn wood to be supplied, specifications of the products to be made, the unit of measure and price per unit to be paid -will be stipulated. Periodical revision of contract will be made by both parties so as to adjust the changes in the cost of sawing. This system mainly exists in Calicut, Baliapattam and Perumbavoor areas.

4.4.3 Custom sawing

Under this system, logs which are brought by the merchants or consumers are converted into sizes on the prevailing sawing charges without any eontract. In a mill where there exists contract sawing, custom sawing will get only second preference as the former provides a perennial income to the sawmill owners. Custom sawing prevails in majority of the sawmills in Kerala.

4.5 Raw material supply

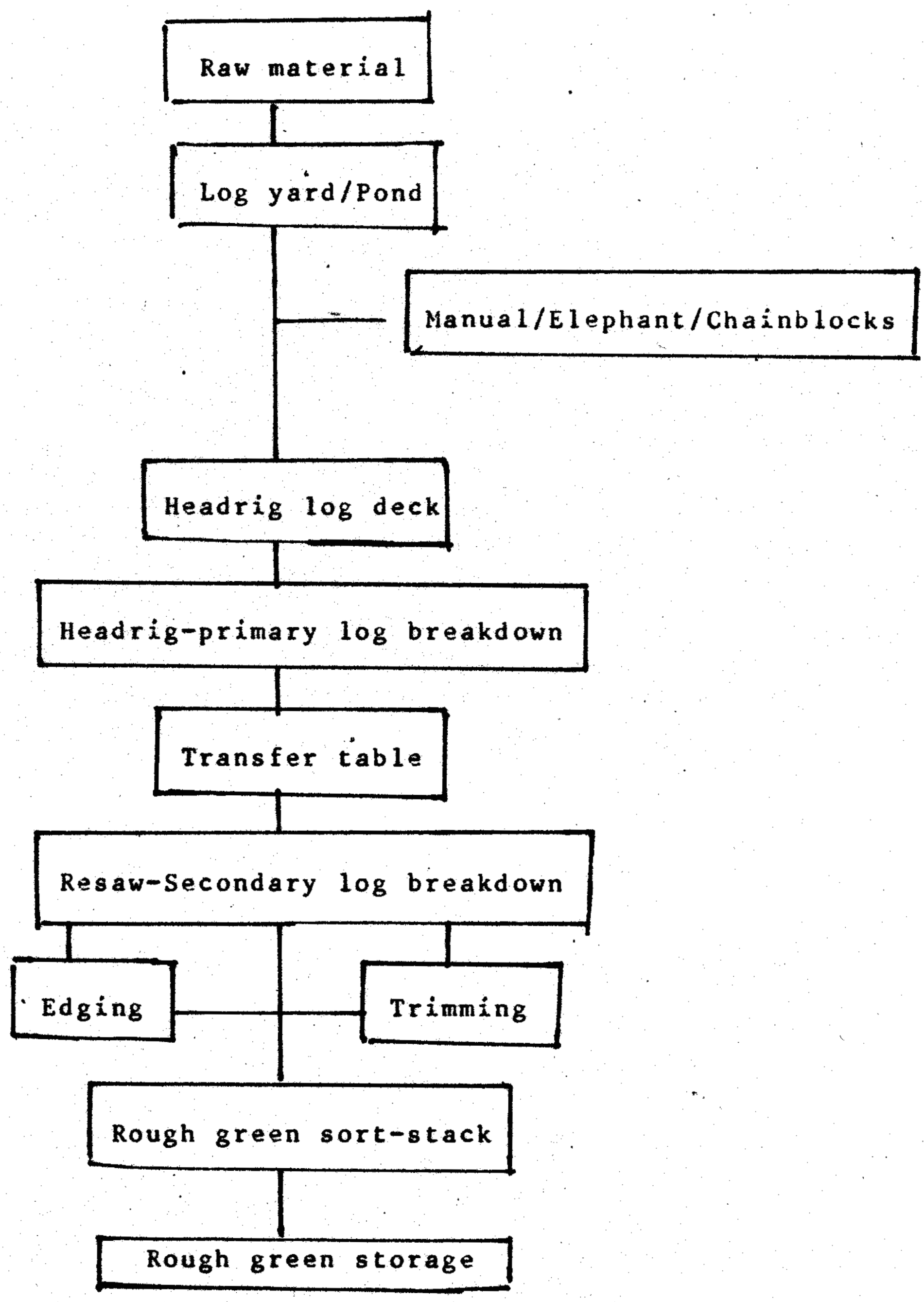
The continuous supply of suitable raw material is a basic need for the sustenance of any industry and sawmilling is not exception to this. There must be sufficient quantity of timber available to operate the mill at maximum capacity. But the current situation of raw material in Kerala is very precarious.

Sources of supply of timber are identified as forests, estates, house compounds and imports. House compound is the major source of supply of timber to the sawmills, accounting for 32% and is followed by import and estate which constitute 29% and 27% respectively. Supply from forests accounts for only 12%.

In southern Kerala (Ernakulam and Quilon districts), during the period of this study, government forest depots, estates, house compounds and other local forests appeared to be the major sources of raw material whereas in northern part of Kerala (mainly Calicut and Cannanore districts), import of round wood from other states (Assam, Orissa, Bihar, Karnataka, etc.) as well as overseas (mostly Malaysia and Burma) was a more prevalent practice. In central Kerala (Trichur) the situation was somewhat intermediate.

5. Existing technology

In order to evaluate the existing technology, a flowchart showing different units of operation is given below.



5.1 Raw material characteristics

The commonly processed timber species (during the period of this study) with their wood density and possible end-uses are listed in Table 3. The timber processed may vary from as soft as the wood of semul and cashew to as hard as the wood of mesua and coconut, the wood density range (at 12% moisture content) being 365 - 1090 kg/m^3.

5.2. Logyard

Although, log yard is an important part of the mill which performs the function of receiving, storing, sorting, log inventory and supplying the logs to the deck for primary conversion, none of the mills surveyed had all the facilities in the log yard for fire prevention and log protection against the heat of sunlight, However, some mill yards have trees for shade. Many logs lying in the yard showed severe end splitting due to fast drying under run (Fig. 1) which could have been avoided to some extent by sprinkling water.

Table 3

Commonly processed saw timber species in Kerala

	Species	Trade name	Local name	Wood density (kg/m^3) at 12 % m poisture content	Uses
1	Albizia lebbek	kokko	vaga	640	Co,Fu,T.
2	A. odoratissima	kala-siris	kunnivaga	735	Co,Fu,T.
3	Anacardium occidentale	cashew wood	kasumavu	425	Lp.
4	Artocarpus heterophylla	jack, kathal	pilavu	595	Co,Fu,Tur.
5	A. hirsutus	aini	anjili	575	Co,Fu.
6	Bombax ceiba	semul	elavu	365	Lp.
7	Calophyllum sp.	poon	punna	695	Co,Fu,T.
8	Cocos nucifera	coconut palm	thengu	761	Co,Fu,T.
9	Dalbergia latifolia	rosewood	veeti	815	Co,Fu,Hp,T,Tur.
10	Dipterocarpus indicus	gurjan	kalpayin	785	Co,Hp.
11	Dysoxylum malabaricum	white cedar	vella agil	720	Co,Fu,Hp,Tur
12	Grevillea robusta	silver oak	silver oak	640	Co,Hp.
13	Grewia tiliifolia	dhaman	chadachi	785	Co,Fu.
14	Hevea brasiliensis	rubber wood	rubber	560	Co,Lp.
15	Hopea parviflora	hopea	thambagam	930	Co,T.
16	Hymenodictyn excelsum	kutnam	vellakadambud	510	Lp.
17	Lagerstroemia microcarpa	venteak	peruntholi	640	Co,Fu,Hp,T.Tu.
18	Lophopetalum wightianum	banati	venkotta	465	Fu,Lp.
19	Mangifera indica	mango wood	mavu	690	Co,Fu,Hp.

Fig 1 Logs stored in log yard without any protective mesures

Fig 2 Log pond of the mills located besides the river

Fig 3 Log hailing by an elephant

20	Mesua ferrea	mesua	churuli	1090	Co,T.
21	Palaquium ellipticum	pali	pali	690	Co,Fu,Hp.
22	Pterocarpus marsupium	bijasal	venga	800	Co,T.
23	Switenia spp.	mahogany	-	-	Co,Fu.
24	Tectona grandis	teak	thekku	650	Co,Fu,T,Tur.
25	Terminalia bellirica	behera	thanni	625	Co,Hp.
26	T. crenulata	lausel	thembavu	880	Co,Fu,T.
27	T. paniculata	kindal	maruthu	785	Co,Hp,T.
28	Toona ciliata	toon	-	515	Fu,Hp.
29	Dryobalanops spp.	kapur	-	645,720	Co,Fur,T.
30	Shorea spp.	balau	-	905-1010	Co,Fu,T.
31	Shorea spp.	red balau	-	847-869	Co,Fu,T.
32	Shorea spp.	meranti,balau	-	645-720	Co,Fu,T.

Co= Constructional purpose; Fu= Furniture, Cabinet making; Lp=Light packing; Hp=Heavy packing case; T=Tool handles and implements; Tur= Turnery articles.

One salient feature of sawmills located in northern Kerala, is log pond because of an extensive river system with salt water (Fig. 2). The main advantages of log pond are:

- there is no fire danger in log yard
- fast (uneven) drying and end-splitting of logs are avoided
- water keeps the logs moist and bark loose and soft
- the salt water has some preservative effect on timber.

However, care has to be taken to prevent the attack of teredos and marine borers if the logs are to be stored for longer period. As log pond facility is not available to all the mills, they need to develop other protective measures like frequent water sprays and providing shade.

5.3 Log hauling from storage to processing unit

By and large, log hauling in the yard is performed manually. Using mechanical aids except long levers is rare. In medium-sized mills, manually pulled carts and elephants are used in hauling the logs (Fig. 3). Log dragging, either by using elephants or manually, often results In dirt and stones being included in the log surface which can cause extensive damage to the saw blades. Chain blocks or lifting winches (with monorail hoist) are common in northern Kerala since the logs are to be lifted from the log ponds and conveyed to the headrig deck (Fig. 4). The monorail hoists with winch stated to have a lifting capacity of 5 - 7.5 tonnes, are operated either manually with one to two persons or with motors of about 7 kw.

5.4 Log deck

Log deck is an auxiliary unit, which conveys the logs to the headrig carriage after receiving from the yard. It is simply an arrangement of wooden structures which support the logs in loading on to the carriage. The wooden supports are often arranged a slight downward slope, over which the logs roll or slide by gravity to the loading position. Using manually

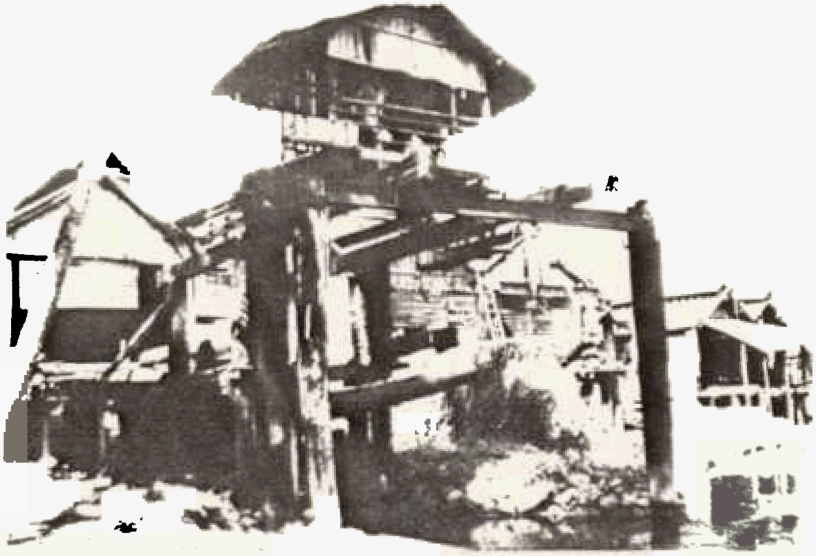


Fig 4 Log lifting from the log pond using a motor and mono-rail hoist with a winch

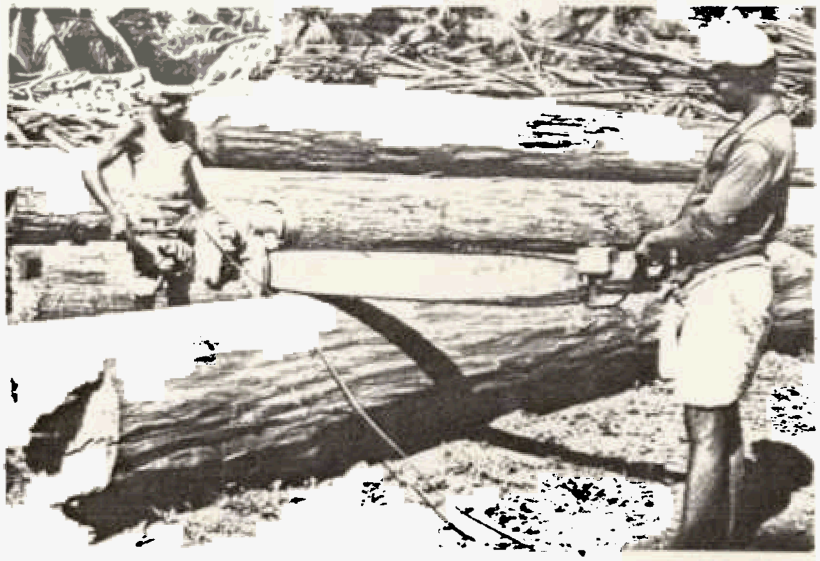


Fig 5 Crosscutting with a power driven chain saw

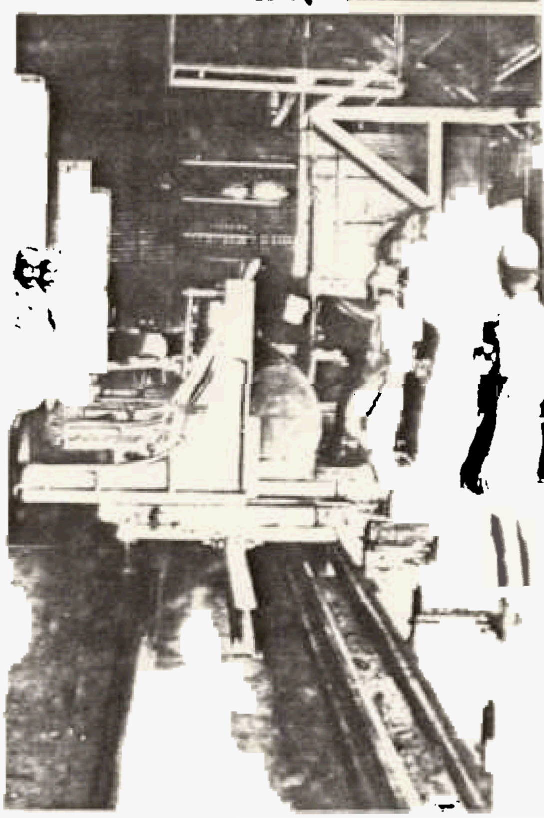


Fig 6

Vertical band headrig with a power driven carriage operated chain blocks to convey the logs to tht carriage is also in practice in older mills.

5.5 Log debarking

Debarking prior to log breakdown is not tound as an integral part of typical sawmill in' Kerala. Although, mechanised debarking may not be justified inthese small mills labour-intensive simple hand tools could be appropriate in the logs. In one or two mills where cashew wood is processed, as a rare feature, debarking is carried out using knife or axe.

5.6 Bucking (crosscutting)

Crosscutting the logs of excessive length before processing is carried out either manually with two men crosscut saws or often with power driven (2.2 kw) Indian made chain saws made in India (Ahamedabad) (Fig. 5 and Appendix).

5.7 Headrig machine (Primary log breakdown)

The primary log breakdown is performed using the main sawmill machine commonly referred to as headrig. Majority of the mills have one headrig band saw while the smallest units do not possess it at all and the larger units often have 2-3 headrig band saws. One noteworthy feature of sawmilling technology in Kerala is that the headrig machines are employed invariably with band saws and none of the mills had headrig circular saw. It is, therefore, believed that sawmills are relatively more efficient in terms of log conversion as thin band saws produce relatively less wood waste in contrast to tho circular saws. Two types of headrig band saws are,

(a) Vertical band headrig (hereafter referred to as type A) with a power driven carriage having four head blocks (Fig.6).

(b) Horizontal band headrig (type B) with a manually operated carriage having four simple vices (Fig.7).

The figures in Table 4 show that the highest number of vertical automatic band sews are used in northern Kerala while in other regions horizontal headrig band saws are more frequent. This technical advancement In northern part is attributable to the well known timber trade in Calieut area during the first half of the century.

Table 4

Number of units having different machineries or sets of machineries in sample sawmills of three zones* in Kerala

Machines	zone 1	zone 11	Zone I11
Vertica1 band headrig saws (automatic)	6	4	32
Horizontal band headrig saws	50	47	7
1 Band headrig saw + 1 band resaw	45	48	18
1 Band headrig saw +2 band resaws	3	1	-
I Band headrig saw+1 circular resaw	--	--	8
1 Band headrig saw+circular and band resaw	2	-	1
Band resaw only	5	6	7
Circular resaw only	1	-	1
2 Bandsaws + 4 circular resaw	1	-	-
5 Bandsaws + 8 circular resaws	-	1	-

* Zone I Ernakulam, Quilon and Kottayarn

Zone II Trichur

Zone III Palghat, Malappuram, Calicut and Cannanore

5.7.1 Vertical (type A) and horizontal (type B) headrig band compared

Type A is known to be more efficient than type B because log beonversion capacity and productivity per man hour are generally greater in the former, In Type A, it is easier to position the log in a desired orientation for maximum outturn in selected sawing pattern and sawing accuracy is greater. Large diameter wheels, with wide saw blades are used in Type A as compared to type B. The technical specifications of two types of headrig band saws may be compared from the values presented in Table 5. Swage set teeth are common in the blades of 6"-7" width while narrower saws aro used with spring-set teeth. The narrow band saws, with spring-set teeth, perform better than wider band saws with swage-teeth in sawing the dense hardwoods having curves and irregular shapes.

5.7.2 Headrig carriage

Log carriage of vertical band headrig is driven by an electric motor of 3.7 to 7.4 kw (5-10 HP) by winding and unwinding a wire rope while that of horizontal type is usually operated with a steering set. The length of most frequently used carriages varies from 4-87 m (16') to 5.48 m (18') with a rail length of 24.38 m (80') to 30.48 m (100'). The maximum diameter of the log that can be sawn is 136 cm (54") with most frequent value of 107 cm

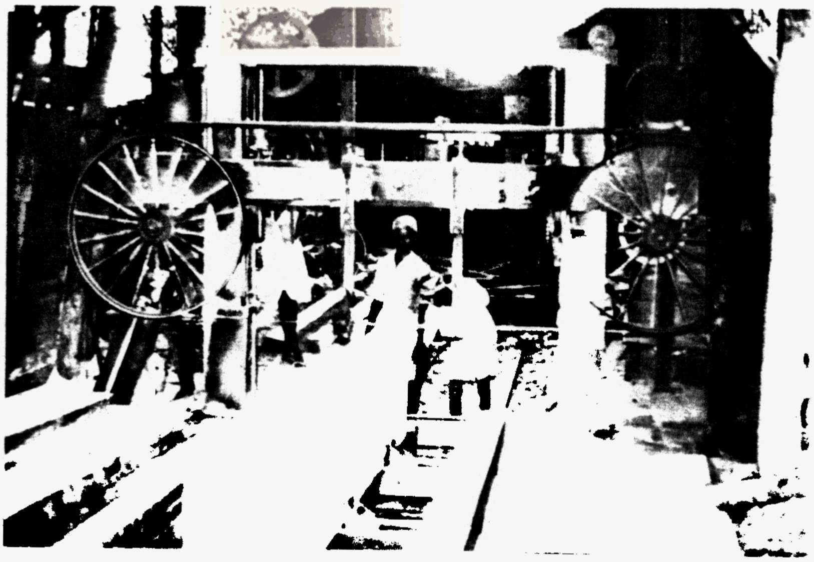


Fig 7   Horizontal band headrig

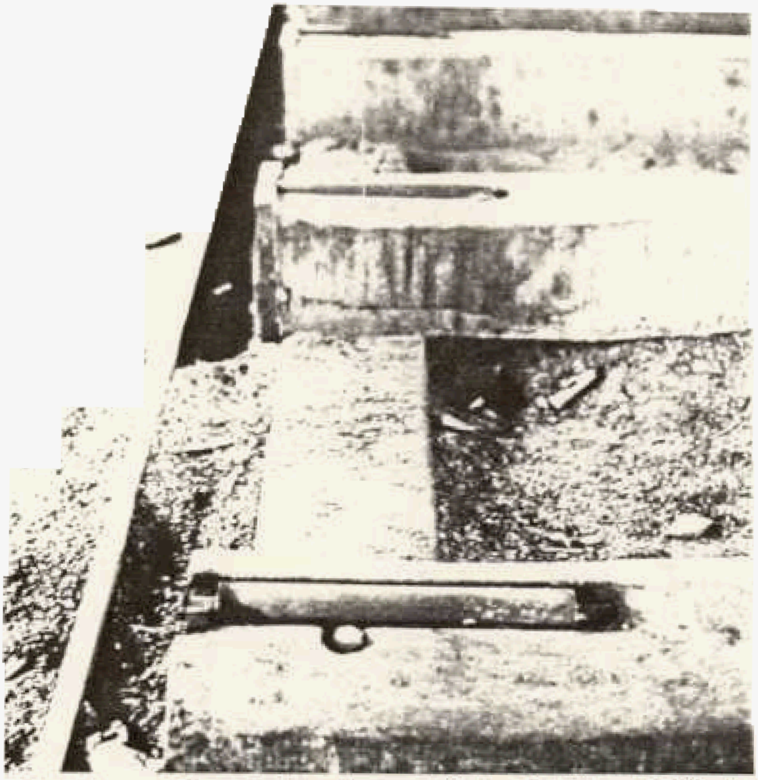
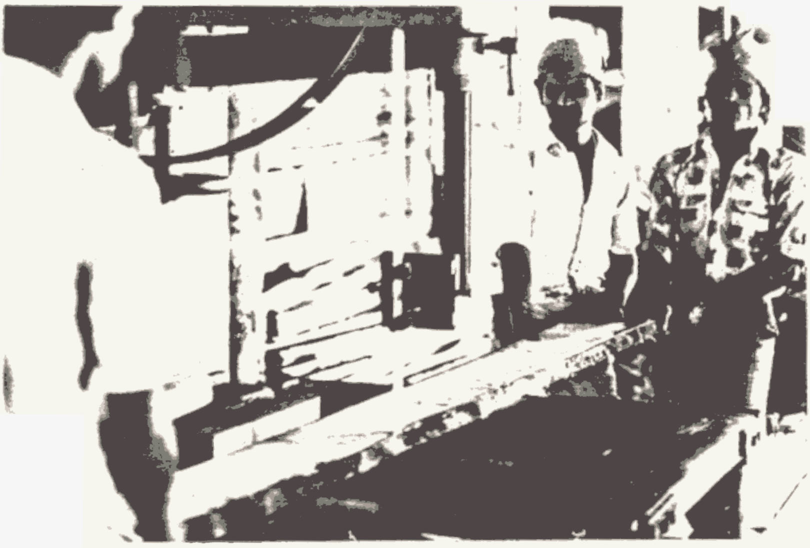


Fig 8   Headrig transfer table with steel rollers



9   Verticai band resaw with hand feeding

Table 5.

Technical specifications of commonly used headrig machines in Kerala

Band saw	Vertical bandsaw	Horizontal bandsaw
1. Wheel diameter	1016- 1524 mm (40"-60")	1066 mm (42")
2. Blade width	102- 178 mm (4"-7")	64-76 mm (2 1/2"-3")
3 Pitch	25- 38mm (1"- 1 1/2")	13-16 mm 1/2"-5/8")
4. Gauge of blade	17-18)	18-19
5 Motor power	18.6- 29.8 kw (25-40 HP)	11.2–15 kw (15–20 HP)
Carriage		
1. Motor power	3.7- 7.4 kw (5-10HP)	Manual
2. Head blocks	4-5 sets and knees	4-5 sets vices
3. Length	5-5.5mm (16'- 18')	5m (16')
4 Rail length	24.4 - 30.5 m (80'-100')	24.4 m (80')

Four or five sets of headblocks and knees are common In the log carriages of vertical headrig while four or five sets of vices are provided in the carriage of horizontal type.

5.7.3 Headrig transfer table

After primary log breakdown, sawn material needs to be conveyed to resawing. This conveying system is so simple that most of the mills have only wooden supports. However, considerable number of units have simple conveying table wooden or steel rollers for easy movement of sawn material with man power (Fig. 8).

5.8 Resaw machine (Secondary log breakdown)

Resaw machines are used to breakdown the slabs or cants that Come from headrig machines. They are also used to prepare suitable sizes by ripping the cants into narrower widths. Vertically mounted band resaws with hand feeding system is most frequent in the mills of southern and central parts of Kerala (Fig. 9) while circular resaws are not replaced by band resaws In Calicut and Cannanore areas as evident from the Table. 6. (Fig. 10).

5.8.1 Circular resaws

The technical specifications of various circular resaws used in Kerala are presented in Table 6. Some mills in northern Kerala use old imported circular saws while a number of other units use Indian-made circular resaws.

5.8.2 Band resaw

The technical specifications of band resaws are given In Table 6. The guage of these bandsaws is 18 or 19 contrast to 13-17 of circular resaw and hence saw kerf waste with band resaw is much less as compared to the circular resaws.

Fig 10 Circular resaw

Fig 11

Sawmill integration with furniture-making

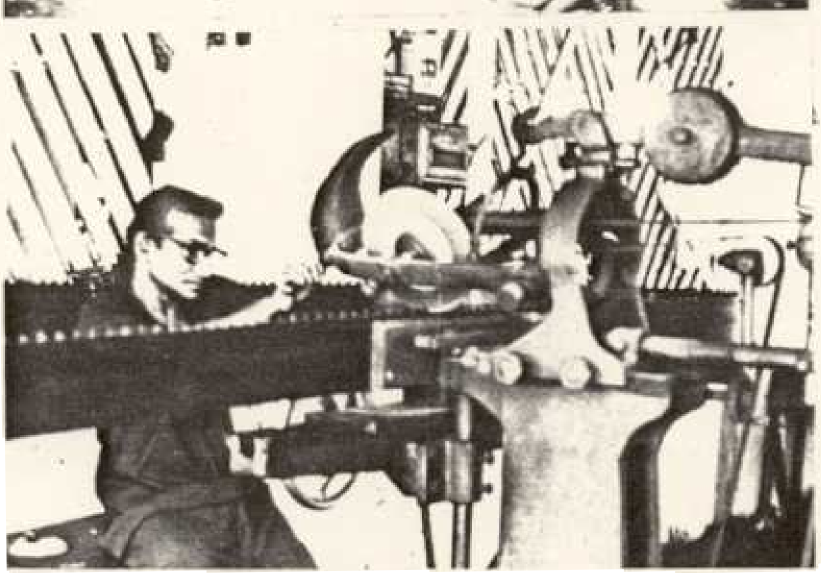


Fig 12 Automatic grinder

Band resaws are mostly manufactured locally in lndia. (See appendix for the list of local manufacturers).

5.9 Edging and trimming

In modern,sawmills, the edger is used to produce boards with parallel sides and to remove the wane or rounded edges from the boards. Its additional function is to divide the cants length wise into suitable sizes.As this function is normally performed by semi skilled workers using resaws no such separate operation units are found in the sawmilling system In Kerala.

Trimming is the process of crosscutting timber to square ends or to remove the defects. In nany mills trimmers are not used with the pretext that most of the sawn goods they produce do not require trimming since the defects or the bad ends nerd to be trimned only if the timber is to be planned subsequently within the mill. Nevertheless, in a considerable number of units (especially In Ollur area) trimming is done with single or 2-saw trimmers when the units are engaged in the supply of packing case frames and furniture items (Fig.11). Technical specifications of the trimmer are presented in Table 6.

Table 6

Technical specification of most commonly used resaw in Kerala

Band resaw

1. Wheel diameter	610- 1067 mm (24" - 42")
2. Blade width	63.5-76 mm (2 1/2" -3")
3. Saw gauge	18-19
4. Pitch	13- 15.8 mm (1/2"- 5/8")
5. Motor power	7- 25 kw (10- 25 HP)

Circular resaw

1. Diameter	610- 762 mm(24" - 30")
2. Saw gauge	13-17
3. Pitch	19- 38 mm (3/4" - 1 1/2")
4. Motor Power	7.4- 11.1 kw (10-15 HP)

Trimmer

Circular saw diameter range	305- 457 mm (12"-18")
pitch	19 mm (3/4")
gauge	14
power	3.7-7.5 kw (5-10

5.10 Blade maintenance

Saw blade maintenance involves straightening or tensioning, tooth setting, swaging and sharpening the blade (by grinding the gullet or filing). Mostly these functions are performed manually. Grinding is normally done with hands or hand-controlled operation. However automatic grinders with 0.74 kw(1 HP) motor and a feed speed of 40 to 84 teeth per minute are not very rare. (Fig. 12)

Where teeth are swage set., they are not swaged with a modern swaging tool instead the tip of the tooth is punched with hammer. In spring-set teeth of bandsaws, which is most common practice, the tips of the teeth are to be bent to the left and to the right alternately by 1/3rd of the blades thickness. The amount of setting is not controlled or measured. When the saw blades are swaged, the swaging is done by hand and the side dressing is not done. Stellite tipping is not used, despite the need of processing very hard wood with silica contents.

To sum up the machineries, a typical sawmill In Kerala has a vertical or horizontal band headrig, circular or band resaw, occasionally a trimmer/crosscut saw and a grinder. The number of these machines may be more than one in relatively large mills. Smallest units may function even with single resaw (Table 4) Most of the units have Indian-made machineries (See Appendix for list of manufacturers) with the technical specifications of Belgium machines (Brenta-band saw). However, in northern Kerala, many mills still use old Belgium machines for efficient sawing.

5.11 Layout of Sawmills

A typical mill has either 'L' shaped or 'I' shaped layout. The former type has anyone of the two patterns of machinery locations in the mill (Fig 13a and b)

The 'I' shaped mill is most common in northern Kerala, where the logs are stored in log pond at one end of the 'I' (Flg.13c). Headrig machines and resaws are in one line in this type of layout. Very small units having single resaw also have 'I' shaped layout with an adjacent log yard.

5.12 Power consumption

Information on power consumption (kw) per unit in sample sawmills is furnished in table 7.

Table 7 Power consumption in selected sawniills in Keralo

(kw)

	Zone I*	Zone II**	Zone 111***
	Mean(Range)	Mean(Range)	Mean(Range)
Log handling	-	-	4.0 (0-7.5)
Headrig	17(15-60)	19(15-150)	28 (15-65)
Resaw	15 (10-20)	15(10-25)	11 (7-15)
Trimmer	6 (5-10)	6(5-10)	6 (5-10)
Grinder	0.75	0.75(1-3)	0.75
Total	38	40	49

* Ernakulam, Quilon, Kottayam districts

** Trichur

*** Palghat, Malappuram, Calicut and Cannanore

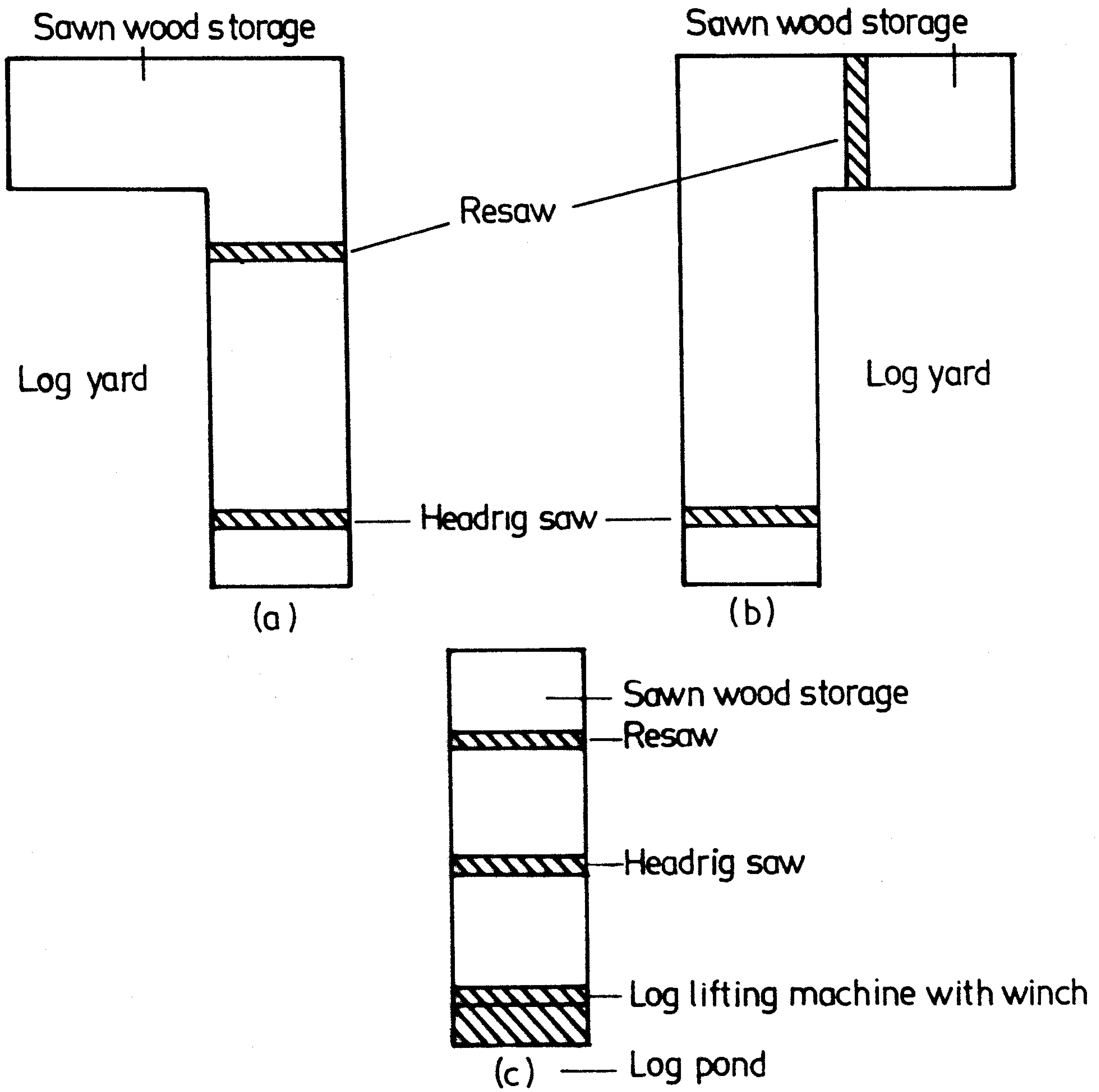


Fig 13   Different layouts of the sawmill

6. Ownership and Management

Except very few units in public and co-operative sectors, all other sawmills in the state are in the private sector. Of the total 165 samples, about 73 units accounting for 45 percent are under proprietorship and rest are partnership firms. There are two types of partnership firms in the sawmilling industry, those formed by family members and- those by outsiders. The former constitutes about 78% of the total partnership firms in the sample.

The management in a proprietorship firms is carried out by the proprietors who are often assisted by their family members, while in partnership firm, it is done by the managing partners with the assistance of other partners. Some of the sawmills in the state are closely integrated with the other allied activities such as log business (depot) and packing case production. However, with a view to get tax exemption, the subsidiary units are registered separately although they are managed or controlled by the sawmill owners.

7. Structure and composition of capital

An attempt is made in this section to examine the structure and composition of various types of capital viz. fixed capital, working capital, and productive capital employed by the saw milling industry.

7.1 Methods of valuation

Fixed capital consists of item such as land, factorv buildings (includinn furniture) and p1ant and machinery, while working capital constitutes stock of raw materials, fuels and lubricants, stock of finished and semi-finished products, hand and at the banks, etc. The valuation of working capital does not present much problem since Its value can be worked out from the books of account. On the contrary, the valuation of fixed capital is a stupendous task, partly because of non-availability of accurate data on values of various items of flxea capital and partly due to lack of uniform method of estimation of depreciation.

In this exercise, the valuation of fixed assets of the saw mills is carried out on the basis of historical cost. During the sample survey, it was found that a significant number of sawmill owners had maintained accounts on the values of the fixed assets they possessed and, therefore, this has been taken the historical costs of the fixed capital their case. In the case of those who did not maintain the accounts, the historical cost was worked out on the basis of values of the similar items given by other sawmill owners in the locality.

There has not been any uniform method of estimation of depreciation among the sample units. In medium sawmills, which pay income tax, the depreciation is worked out at the rate prescribed by the Income Tax Authorities, that is 10% for machinery and 5% for factory buildings. But in majority of other units, tho depreciation is worked out at a uniform race of 52. both for buildings and machineries. As non-taxable units are dominated in our sample depreciation at the uniform rate of 52 is provided for machineries and factory buildings.

7.2 Fixed capital

The composition of fixed capital in two size groups is shown in Table 8. Fixed capital employed per unit in small size group amounted to Rs.90000 while it is Rs.122000 in medium size group, with ordinary bandsaw. In other words, fixed capital employed by the sample sawmills shows increasing trend with size. The fixed capital of medium size with automatic band saw stood as Rs.190000. Plant and machinery is the single largest item of expenditure in two size groups.

Table 8

Fixed capital employed per unit (size-wise)

(Rs.)

Item	Small	Medium
Land	25093	39361
	(27)	(32)
Building	14992	23227
	(17)	(19)
Plant and machinery	49731	59805
	(56)	(49)
Total	89816	122393

Figures in the parentheses are percentages to total

7.3 Working capital

Table 9 provides details of working capital in two size groups. Working capital employed per unit amounts to Rs.222000, while it is Rs.360000 in medium size group. In both size groups, investment on raw material is the most important component of working capital, which accounts for 60% and 67% in small and medium size groups respectively. This is followed by remuneration to workers - wages, salary and non-wage benefits. In small units, remuneration to workers (31%) is found to be higher than that in medium size group (26%), indicating that small size units are more labour intensive. Like fixed capital, the working capital employed per unit also showed an trend with size.

Table 9

Working capital employed per unit (size-wise)

(Rs.)

Items	Small	Medium
Stock of raw material (finished and semi-finished goods)	134388	240089
	(60.56)	(66.54)
Salary	12810	17550
	(5.76)	(4.94)
Wages	45883	63276
	(20.66)	(17.53)
Non-wage benefit	9756	13063
	(4.39)	(3.61)
Net balance of current assets and liabilities	8524	10902
	(3.83)	(3.02)
Fuel	5076	7523
	(2.28)	(2.08)
Miscellaneous	5612	8232
	(2.52)	(2.28)
Total	222049	360935

Figures in the parentheses are percentages to total

7.4 Productive capital

Table 10 furnishes details of productive capital which consists of fixed assets and working capital. The productive capital employed per unit in small size group is estimated *to* be Rs.311000 of which fixed and working capital account for 29% and 71% respectively. The productive capital employed by medium size group amounts to Rs.480000. The proportion of working capital to total productive capital as in small size group, is found to be higher in medium size group, accounting for 75%.

Table 10

Gross productive capltal employed per unit (size-wise)

(Rs.)

Item	Small	Medium
Fixed capital	89816	122393
	(28.79)	(25.32)
Working capital	222049-	360935
	(71.21)	
Total	**311865**	**483328**

Figures in the parentheses are percentages to total

7.5 Net productive capital

Details of net productive capital consisting of depreciated value of fixed capital (excluding land) and working capital are presented in Table 11. As expected the proportion of fixed capital to total net productive capital declines in both the size groups, because of the depreciation of the two fixed capital assets viz. building and plant and machinery. Further, the proportion of fixed capital to net productive capital shows a decreasing trend as the size of the units increases, which implies that some of the medium size units are older than small units in the sample.

Table 11

Net productive capital employed per init (size-wise)

(Rs.)

Item	Small	Medium
Net fixed capital	68876	98246
	(23.67)	
Working capital	222049	360935
	(76.33)	(78.61)
Total	290925	459181

Figures in the parentheses are percentages to total

7.6 Structure and composition of capital and different types of sawmill

An attempt is made to examine the changes in the structure and composition of capital where the sawmills are integrated with allied activities. The sawmills are grouped into three: sawmill, sawmill with depot and, sawmill with depot and packing case production[4].

The analysis of data indicates that the structure and composition of capital are likely to be changed, when the saw mills are attached with other allied activities. Table12 presents gross fixed capital employed per unit by two size groups of three types of sawmills. Whether integrated or not, the gross fixed capital employed per unit has shown an increasing trend with the size. However, the increase is more pronounced in an integrated sawmill. This is mainly because when the sawmills are integrated with other subsidiary units, more land, machineries etc. have to be acquired, resulting in more investment.

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4 Some sawmills in the state are integrated with the other allied activities such as joineries, wood working and plywood. Although they are the part of the sawmill, these units registered separately in different names. The owners of the sawmill were reluctant to provide information on &he allied units therefore, they could not be treated separately.

Table 12

Gross fixed capital employed per unit (according to types of sawmill)

(Rs.)

Category	Items	Sawmill	Sawmill + Depot	Sawmill + Depot + P. case
Small	Land	21450-	25775	27938
		(26.99)	(28.13)	(28.50)
	Building	11776	15030	17983
		(14.81)	(16.40)	(18.33)
	Plant &	46254	50850	52139
	Machinery	(58.20)	(55.47)	(53.17)
	Total	79480	91655	98060
Medium	Land	34782	39573	43803
		(31.60)	(32.00)	(32.88)
	Building	19220	23280	27023
		(17.45)	(18.81)	(20.28)
	Plant &	56102	60850	62389
	Machinery	(50.95)	(49.19)	(46.84)
	Total	110104	123703	133215

Figures in the parentheses are percentages to total

The same trend can also be observed in theuse of working capital employed per unit by two size groups of three types of sawmills (see Table 13 and 14). Noreover, the working capital employed per unit is increased with increase of integration with allied activities even within a size group. For instance, in small size group, the working capital employed. per unit by a saw mill amounted to Rs.92000 as against Rs.240000 in sawmill with depot and Rs.320000 in sawmill with depot and packing case production. One reason is that the stock of raw material is significantly higher in an integrated nil1 and the same increases with increase of integration. The trends shown by fixed and working capital are maintained by the productive capital (see Table

Table 13

Working capital employed per unit - according to types of sawmill (smell size)

(Rs.)

Item	Sawmill	Sawmill + Depot	Sawmill + Depot + P. cases
Stock of raw material (semi finished and finished goods)	22500 (24.33)	160396 (64.30)	220035 (67.79)
Salary	8910 (9.63)	12275 (4.91)	17670 (5.40)
Wages	38321 (41.43)	46430 (18.62)	52660 (16.27)
Non-wage benefits	7994 (8.64)	9520 (3.82)	11714 (3.60)
Balance of current assets & liabilities	6584 (7.12)	9825 (3.93)	9622 (2.96)
Fuel	4445 (4.80)	4852 (1.94)	5970 (1.83)
Miscellaneous	3754 (4.05)	6212 (2.48)	6964, (2.15)
Total	92508	249510	324840

Figures in the parentheses are percentages to total

Table 14

Working capital employed per unit - according to types of sawmill (medium size) (Rs.)

Item	Sawmill	Sawmill + Depot	Sawmi11 + Depot + P. cases
Stock of rawmaterial, (semi-finished and finished goods)	51000 (34.26)	284975 (70.18)	384605 (72.82)
Salary	14180 (9.53)	16845 (4.14)	22209 (4.20)
Wages	54321 (36.50)	62717 (15.44)	72729 (13.76)
Non-wage benefits	10227 (6.86)	13060 (3.23)	16106 (3.04)
Balance of current assets & liabilities	6876 (4.63)	12724 (3.13)	13380 (2.53)
Fue1	6699 (4.49)	7231 (1.78)	8677 (1.65)
Miscellaneous	5583 (3.74)	8582 (2.11)	10591 (2.00)
Total	148886	406134	528297

Figures in tho- parentheses are percentages to total

Table 15

Fixed capital, working capital and productive capital employed per unit (according to types of sawmill)

(Rs.1

Category	Items	Sawmill	Sawmill + Depot	Sawmill + Depot + P. cases
Small	Fixed capital	74460	91655	98000
		(46.21)	(26.86)	(23.18)
	Working capital	92508	249510	324840
		(53.79)	(73.14	(76.82)
	Productive capital	171986	341165	422900
Medium	Fixed capital	110104	123703	133215
		(42.51)	(23.34)	(20.13)
	Working capital	148886	406134	528297
		(57.49)	(76.66)	(79.87)
	Productive capital	258990	529837	661512

Figures in the parentheses are percentages to total

7.7 Relationship between size and capital

In the foregoing section, the relationship between size and different types of capital used in the industry are examined using simple averages. One of the drawbacks of this analysis is that the values of size and capital are unduly influenced by extremr values in the distribution resulting thereby losing of reliability of the result. To overcome this defect, the relationship is tested with appropriate regression function. As there exists a linear relationship between size and capital, tho linear regression model has been selected for the analysis.

The selected regression model takes the form

$$Y = a + b X$$

where Y = size as measured by production capacity

X = capital

The relationship between the size and different types of capital - fixed, working capital and productive capital - is shown in Table 16. Based on the sign of regression coefficient, it may be inferred that there exists a positive relationship between size and different types of capital.

Table 16

Relationship between size and different types of capital

	Variables	No. of observations	Equations	R^2
1	Y and X_1	165	$Y = 99.7006+0.3202X_1$ (0.6467)	0.53*
2	Y and X_2	165	$Y = -15.2316+0.7151X_2$ (0.2057)	0.88*
3	Y and X_3	165	$Y = 6.9433+0.4066X_3$ to	0.76*

Y - Size

X_1 - Fixed capital

X_2 - Working Capital

X_3 - Produtlve capital

* - Indicates significant at 1% level

Figures in the parentheses are standard errors.

8. Capacity utilisation

The difference between nominal maximum capacity, that is installed capacity as determined by the capacity of headrig and present production is taken as an indicator of capacity utilisatlon in the industry. At present, the sawmilling industry is faced with difficulty in operating even one shift continuously throughout the year, therefore, for the estimation purpose, maximum capacity in one shift is equated with nominal maximum capacity. Here nominal maximum capacity is defined as the output potential of a unit If it was assumed to continuously operate one shift *(8* hours per day) in a year *(290* days).

Information on nominal maximum capacity and present production according to size groups is turnished in Table 17. The average capacity utilisation in sawmilling industrv is of the order of 53%. This indicates that output and employment in the industry can be augmented by working full capacity without additional investment. As the table shows, the capacity utilisation is positively related to the size of the units, for instance, the average capacity utilisation in smal1 size group accounts for 47% which rises to 59% in medium size group. One explanation for this is that larger units have more stock of raw materials.

Table 17

Capacity utillsatlon in sawmilling industry in Kerala

size (1)	Maximum production capacity (2) (m^3)	Present production capacity (3) (m^3)	Capacity utilisation (as percentage of 3 to 2) (4)
Small	1,400	662	47
Medium	1,800	1070	59

Capacity utilisation is increased not only with the size of the mill but also with integration with other allied activities (see Table 18). The integrated sawmills are supplied with more timber and this may be a major reason for the above trend.

Table 18

Capacity utilisation in different types of sawmill

(m^3)

Category	Small	Medium
Sawmill	506	944
	(36)	(52)
Sawmill + Depot	689	1085
	(49)	(60)
Sawmill + Depot +	793	1183
Packing case	(57)	(66)

Figures in tho parentheses are percentages of capacity utilisation to maximum production capacity of the respective size class

About 73% of the unutilised capacity in the sawmllling industry is contributed by shortage of raw material, while 18% by low demand. The low demand for sawn wood is duo to higher price which is, in turn, contributed by decline in the supply of timber. Thus, the first two reasons for under utilisation of capacity are related. The other two reasons for under utilisation of capacity in the sawmilling industry are shortage of power supply and lack of finance which account for 5% and 4% respectively.

9. Profitability in sawmilling

Generally, the profitability of a business enterprise can broadly be judged by studying the income and cost structure. Guided by this, an attempt has been made here to work out gross value of output and cost structure of the sawmills surveyed.

9.1 Gross value of output

Gross value of output is the exfactory net selling value of all goods and services produced by the industry in a given period. This is nothing but, gross revenue received by the units. The gross value of output comprises value of inputs and rewards to factors of production. Gross profit is worked out by deducting gross expenditure - values of rent, depreciation, Inputs, wages and salary to hired labour - from the value of gross output. Thus, gross profit is a residual income which includes the items like remuneration to owners and their family, taxes on income, interest, etc., In addition to net profit. Depreciation is worked out at a uniform rate of 5%, as is practised in the industry. Imputation of remuneration to goods and services supplied by the owners and their family, is a difficult task and often leads to controversy, but is inevitable for accounting purposes. Thus, the entire residue is considered as the remuneration for the services of the employers. This is likely to give some inflated picture of what is indicated as profit of the unit.

The details of gross output produced per unit for two size groups are shown in Table 19. The gross value of output per unit in small size group is estimated as Rs.217000 while it is Rs.340000 in medium size. Input is the most important constituent of tho output, which accounts for 48% In small size, 51% in medium size and is followed by remuneration to workers - salary, wage and non-wage benefits - which constitutes 32% in small size and 28% in medium size groups. Rent formed a very small part of the output of the sample units and constituted 3% In small and medium size groups. Gross profit works out to 17% insmall size and 19% in medium size groups. Significantly, table reveals a positive relationship between inputs used and gross profit per unit; higher the proportion of inputs used larger will be the gross profit per unit.

Table 19

Constitutents of gross output per unit according to size

(Rs.)

Item	Small	Medium
Inputs	104635	172800
(materials and fuels)	(48.20)	(50.74)
Wages, salary and	68445	94465
non-wage benefit	(31.50)	(27.72)
Rent for land and	6885	10060
buildings	(3.16)	(2.95)
Gross profit	37240	63350
	(17.14)	(18.59)
Total	217205	340675

Figures in the parentheses are pecentages to total

9.2 Cost structure

The cost of production in a sawmill consists of inputs (timber), fuels and lubricants, remuneration to workers, rent, interest, tax, depreciation end net profit. Profit **is** a reward for large number of factors such as uncertainty, risk bearing, management, etc. involved in running the business. In small enterprises, the elements of profit such as interest for capital invested by the employers, rent for land and building owned by the employers, wages for work done by employers and family, etc. are cost items (mainly inputed) and therefore, it is treated as cost by many economists (Dhar 1958). One advantage of treating profit as a cost is that it makes the total value of inputs, by definition equal to total value of output. Table 20 furnishes details on various constituents of cost according to size. Expenditure on timber is the most important element of coast in two size groups and is as high as 46% in small size and 49% in medium size groups. The percentage of cost of inputs in small size group in the sample is low partly because they use only less quantity of timber and partly due to the fact that a significant number of small sawmills engage only in cutting low value wood (mainly rubber and coconut) into sizes. The cost on fuel and lubricants in the sample constitutes 2% of the total cost in two size groups.

Table 20

Constituents of total expenditure per unit in different size groups

(Rs.)

Items	Small	Medium
Timber	99685	165260
	(45.90)	(48.52)
Fuels and lubricants	4950	7540
	(2.27)	(2.22)
Wages, salary, non-wage	68445	94465
benefit, etc	(31-53)	(27.72)
Interest	13585	19790
	(6.25)	(5.80)
Depreciation	5355	8270
	(2.46)	(2 0.42)
Tax	1655	4860
	(0.76)	(1.42)
Rent	6885	10060
	(3.16)	(2.95)
Net profit	16645	30430
	(7-66)	(8.95)
	217205	340675

Figures in the parentheses are prcentages to total

The proportion of remuneration to workers is found to be higher in small size groups. This is mainly because, most of the pre-sawing operations in the yard viz. handling of logs, stacking, etc. are done manually in small size group as against these are done with hired elephants or machineries (winches) in majority of the medium size mills. Interest is another important constituent of cost. Depreciation constitutes about 2% in both the size groups. Tax, which includes licence fee, local taxes etc., constituted only very small proportion of total cost in both the size groups. Further the table rrveals that all the size groups earn profit and the net profit per unit is positively related with size. The profit is higher in medium size group, partly because of better stock of timber, indicating that the availability of timber is the crucial factor in running the sawmifling business successfully.

9.3 Value added by manufacture

Value added by manufacture is the difference between the cost of goods purchased by an enterprise and value of the product it sells. This is worked out by deducting the value of raw material, fuel and lubricants, and depreciation from the gross value of output. This contains values of many other items including services purchased from other sectors of the economy (Deshpande 1973). Deducting the valuos of all these items from gross value added provides net value added by manufacture. The details of net value added by manufacture per unit according to two size groups are given in Table 21.

Table 21

Distribution of net value added per unit

(Rs.)

Size group	Labour	Interest	Tax	Net profit	Total
Small	68445	13585	1655	16645	100330
	(68.22)	(13.54)	(1.65)	(16.59)	(100.00)
Medium	94465	19790	4860	30430	149545
	(63.19)	(13.23)	(3.24)	(20.34)	(100.00)

Figures in the parentheses are percentages to total

Net value added by manufacture in small size group amounts to Ks.100000 while it is Rs.149000 in medium size group. In other words; as size of the units increases, the net value added by manufacture also increases. Labour shares the highest proportion of net value added in each size group. Interestingly enough, as the size of the unit increases, the share of labour in net value added decreases. For instance, the proportion of net value added shared by labour in small size group accounts for 68% as against it is 63% in medium size group. The share of interest in not value added is about 13% each in both size groups. The tax, the share of government, is found to be very low in the sawmilling industry, since there is no sales tax on sawing. Generally, what the sawmill owner gives in the form of tax is, the licence fee, local taxes, etc. The share of net profit in net value added increases with size, that is, from 16% in small size group, it increases to 20% in medium size group. This implies that medium size group ,is in more advantageous position in sawmilling business.

10. Technical coefficients

Technical coefficients s'how the relationship between various variables such as employment, capital, output, etc. in an industry. An attempt is made here to work out three important technical coefficients in sawmilling industry viz. capital output ratio, investment employment ratio, value-added by manufacture-enployment ratio.

10.1 Capital output ratio

This indicates the relationship between capital and output in an industry, that is quantity of capital required to yield a given unit of output. Thus capital and output are two variables involved in the estimation of capital output ratio. For the estimation, these variables have been defined as follows.

10.1.1 Capital: This term has been defined in two ways,

a. replacement value of fixed capital and technologically necessary working capital

b. book value of fixed assets and technologically necessary working capital (net balance).

In the first definition, the capital includes only the value of plant and machinery[5]. The other two items of fixed capiital viz. land and building have been excluded from the definition, because of the problem of imputation of value. In the second definition book value of fixed capital consists of depreciated value of fixed assets. The items directly related to the production of sawn wood such as timber, fuel and lubricants, etc. are included under technologically necessary working capital.

10.1.2 Output: The term output is defined as net value added by manufacture. One advantage of this definition is that ishows the effectiveness of the factors of production (Deshpande 1973).

The capital output ratios worked out on the basis of replacement cost as well as book value are given in Table 22. It stood as 0.34 in small size group and 0.27 in medium size group, based on replacement cost and 0.33 in small size group and 0.32 in medium size group based on book value. The amount of capital required per unit of output is less in small size group, implying that productivity of capital is higher In small size group.

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[5] In small size group, the replacement cost of machinery amounts to Rs.70000, which while it is Rs.186630 in medium size group.

Table 22

Capital output ratio

Item	Small	Medium
Based on		
1. Replacement cost	0.34	0.2 7
2. Net balance	0.33	0.32

10.2 Investment-employment ratio

The investment employment ratio is computed by dividing the productive capital by the total workers which includes permanent and temporary workers. Investment employment ratio is one of the Indicators of the capital intensity, more an industry is technologically oriented, the more will be investment per person. The investment-employment ratio worked out for the industry appears to be moderate. It amounts to Rs.31186 in small size group to Rs.40,277 in medium size group.

10.3 Net value added-employment ratio

This ratio which is worked out by dividing net value added by manufacture by total number of workers, indicates the average productivity per worker on the basis of present production. Table 23 shows the value added and the wages received per worker. The value added per worker increases with the size of the unit, from Rs.10033 in small size group to Ks.12462 in medium size group. A higher net value added per worker in medium size group As contributed by two factors. First, the capacity utilisation in medium size is higher and therefore production is also higher. Second. the high wage rate existing in the medium size group may have contributed higher productavity. A comparison of value added per worker with wages received per worker shows that the former is significantly higher than the latter.

Table 23

Value added per worker

(Rs.)

Item	Sma 11	Pled ium
Net value added/worker	10033	12462
Annual wage/worker/unit	7192	8847
Surplus/worker	2841	3615

A higher surplus per worker may be contributed by two factors.

1. A part of the labour in the industry was provided by the proprietors and members of their family, therefore, a part of the surplus belong to the proprietors is their remuneration

2. Although the workers are organised on the basis of trade union, their bargaining capacity for higher wages is very weak because of low capacity utilisation and unemployment in the industry.

11. Waste **Utilisation**

The main by-products of the sawmill in Kerala are bark,saw dust,slabs,edgings,trim ends,braken logs and 1imbs.The residues like bark and sawdust are good source of fuel. But in Calicut and Cannanoro areas, since the logs are stored in log pond,wet bark and sawdust need to be dried before using as fue1. Slabs,edgings,trim ends etc.may be used in a better way if the integration between sawmills and other industries such as furniture making units and manufacture of decorative speciality products is strengthened.

There appears to be limited scope for using the wood chips in sawmill units because: **(i)** transportation of chips is not within the economic reach of small-scale milis and **(ii)** chipping operation requires capital investment on chipper infeed conveyor,metal detector,chip screen,chip storage etc which the small-scale industries cannot afford. These units do not even possess efficient chain conveyors for collection, storage and delivery of sawdust in the mills.

In a small-scale modern sawmill power consumption may be higher to produce more lumber per nanhour with appropriate saw tooth functioning which includes tooth speed,feed speed and tooth pitch.The minimum power requirements estimated for such model mills are greater than those of the existing mills. But this will be compensated by the greater productivity of modern mills.

12. Linkages

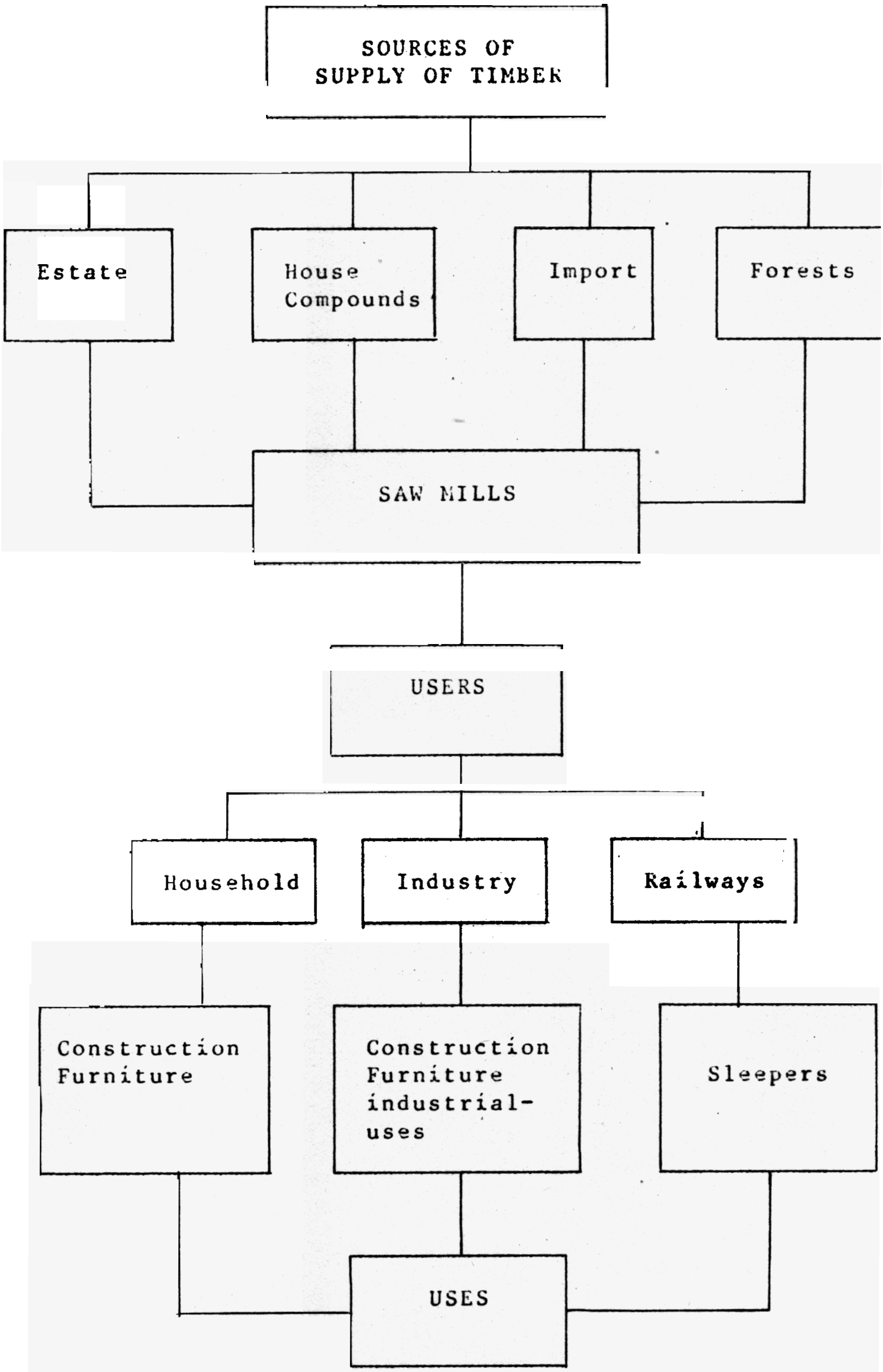
The linkages between supply of timber and enduses of sawn sizes are shown in Figure 14 given below. The major source of supply of timber are estates, house compounds, forests and imports. The logs are procured either by consumer or by timber merchants/sawmill owners. After making sawn sizes the same are given to the respective party who uses or sells it. Major users of sawn sizes are household, industry and railways. The end uses are contruction purposes, furniture making, packing case production and sleepers.

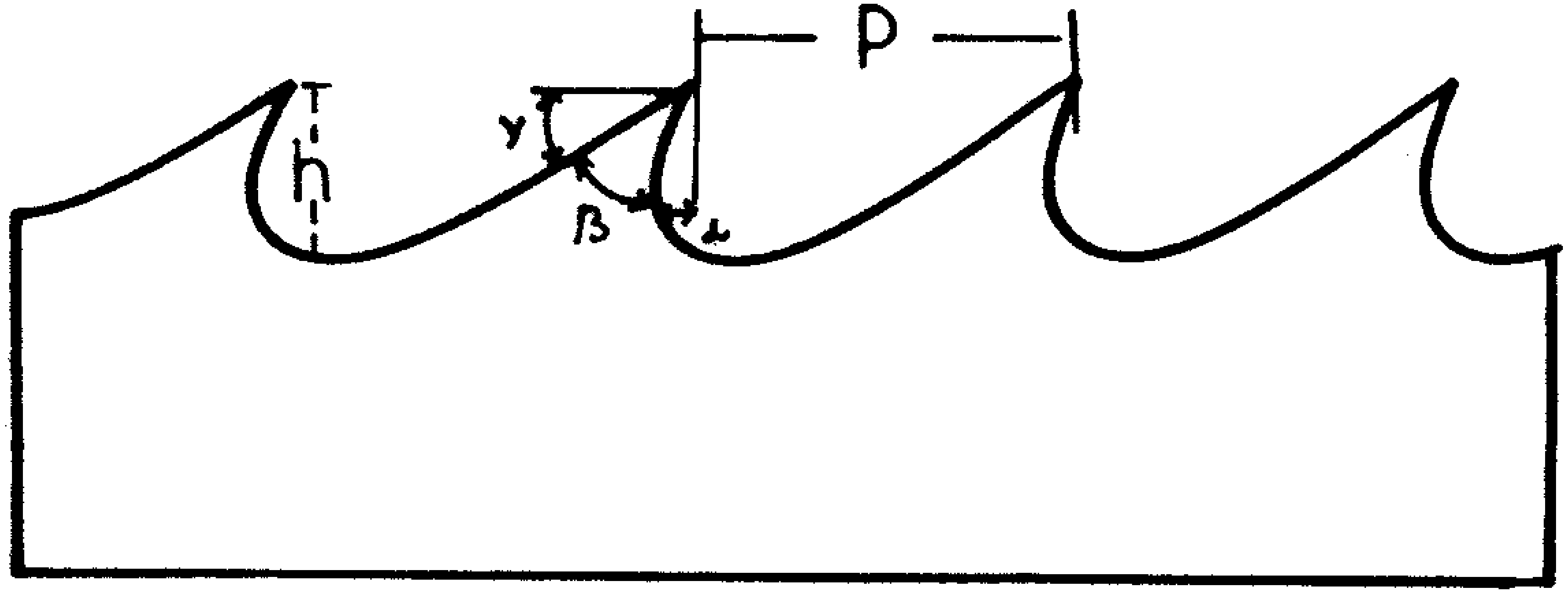
13. Techno-economic aspects

One striking feature of existing sawmilling system is a labour-intensive production flow in the mills. The logs are moved with the help of manually pulled carts or elephants. Similarly, in the mill, sawn material is carried manually or on push wagons from one machine to the next. The final products are also manually sorted and loaded without mechanical aids. In the

Figure 14

Linkages between sources of supply of timber and end uses





p-Pitch, ⍺-Hook angle, β-Tooth angle, r-Clearance angle
h-Tooth height (gullet depth)

Fig 15 Tooth geometry

current system of sawmilling the productivity is rather low i.e. about 50 manhours per m3 (Pelkonen 1986).

Apparently, sawmill industry has no guarantee of sustained timber supply because of inadequate information on standing volume of utilisable species such as aini, coconut, jack, mango and rubberwood in house compounds and estates and because of uncertainty of import-export policy of different states and countries, The situation therefore calls for a long term forestry strategy for the improved supply of sawlogs.

The great diversity of raw material characteristics with a large number of species, resulting in very soft to very hard wood, accompanied by different sizes and properties of logs demands high flexibility in the design of equipments baking the technology more complex in conversion efficiency, For example, headrig machines should be suitable to handle both small diameter logs such as coconutwood and rubberwood and large-diameter lops like mesua, pali and many imported species. At present, the same saw blades are used in processing different species.

Distance of the sawmills from the source of log supply is very variable and consequently the time taken to process the logs in the mill after felling varies from a few weeks (where the wood supply is from house compounds and estates) to several months or often years especially when the roundwood imported from other states and overseas, If roadways (trucks) and railways are the main modes of timber transport, water ways are used to import the logs from other countries. A large number of sawmillers complain that long duration between felling and processing is also due to the delayed auction in government timber depots. Because of long duration between felling and processing, biological log deterioration is significantly high and no protective measures are taken to control decay and stain as well as splitting of logs, in felling sites and mill yards respectively.

The poor condition and maintenance of equipnents including saw blades, can cause problems in lumber grade and recovery as indicated by Swiderski and Neilborn (1983). The survey indicates that most of the sawnillers have poor knowledge of technical aspects of the saws they operate. Furthermore, it was observed that even the local manufacturers of sawmillmachineries were unable to answer how much feed their equipment takes under given conditions. Apparently, no standard or specification is followed for saws, saw speeds and rates of feed and hence using right equipment (of saw) for the job is a matter of chance rather than design. Once the task of a saw **is** known, decisions should be made as to tooth geometry, saw or wheel diameter, tooth pitch, gullet size, side clearance and saw thickness (Lunstrum 1985). Tooth geometry includes setting up the clearance angle, sharpness (tooth) angle and hook angle (Fig.15) hardwood (higher density wood) sawing requires smaller hook angle than softwood sawing. According to the prescription given by Original Volmer (West Germany), the specified tooth angle for cutting teak wood is as follows: hook angle -22° and clearance angle 12°. ln setting up the saw, further decisions may be required on tooth functioning which includes the interaction of tooth pitch, tooth speed and feed speed and finally on power requirements for the set up. If the information is available on feed per tooth (t), log feed speed (f) and width of kerf (k), it is possible to compute net power requirement of bandsaws for cutting hardwood logs.

13.1 Low lumber grade and recovery

It is important to determine how much number is recovered in a mill from each m3 of round wood consumed in order to assess the conversion efficiency of the mill. The lumber recovery factor (LRF) may be obtained as follows:

$$LRF = \frac{m^3 \text{ of lumber produced}}{m^3 \text{ of logs converted}}$$

The LRF figures given by the sawmillers, during the survey, 'range from 50–70% since the present measurement system is based on quarter girth formula, $(G/4)^2 x1$, the real values would be lower by about 21%. This indicates that the present LRF is only in the range of about 30-45%.

It has been well documented that large diameter logs yield more lumber per unit volume of log input (Lunstrum 1982, Steels 1984). Diameter affects LRF especially when logs become smaller. Similarly, log taper, sweep, crook and many natural defects affect the lumber yield overwhich sawmiller has little control. All that he can do is to protect the logs against uneven drying in log yard and to adopt the best sawing pattern.

Kany times, delayed auctioning of logs in timber depots causes considerable fungal and insect damages which would significantly affect the lumber recovery. If the logs contain high proportion of deteriorated material, log diameter may have little effect on lumber recovery. As the delayed log processing is partly due to the administrative procedures of the Forest Department sawmiller can do littlc in improving the lumber grade. The sawmill owner, at present, transfers the loss, incurred due to the degradation of logs, to the sawn goods purchaser and hence he is not interested in improving the storage technology.

Cross cutting the logs either in the mill or in the forest, is another operation unit where some amount of waste can be minimised (Lunstrum 1982).

13.2 Kerf width and sawing variation

In southern and central Korala, narrow saw blades with less thickness (19 guage) are more frequent as compared to the wide and thick blades in northern part. This means that saw kerf width is lower in southern and central parts of Kerala resulting in possibly higher lumber recovery than the northen part. It is probably one of the reasons why the sawmill in ureater pnrt of the state continue to use horizontal band saws with thinner saw kerfs although horizontal band saws have lower capacity of conversion. However, it is important to recognise the fact that the productivity declines with the reduction in saw kerf at the expense of sawing variation (Lunstrum 1982). The sawing variation is nothing but an uneven dimensioning of lumber, due to various factors like saw wander, deviation of log for cut, which is normally greater in these horizontal band headrig mills According to Lunstrum (1982), high recovery mills, on an average, have 25% less sawing variation values than those of low-recovery mills.

Wood waste in terms of oversizing and planing appears to be rather low because of the following reasons:

- In majority of the mills, wood is cut according to the specific requirements of the customer

- Most of the mills do not give any planing allowance, on the other hand, it is found that the dimensions of the cut sizes are lower than the specified values for packing cases Ollur area.

13.3 Sawing pattern

Determination of the best pattern of sawing for each log is important in maximising the lumber recovery and hence it needs particular attention in the existing practice of sawing. Although many sawmillers claim that with their experience it is not difficult for them to determine the sawing pattern for each log, there is a problem of log geometry especially in sawing small-diameter logs and the logs that have flutes, butresses hollows in the centre and severe rots. This is especially true, when sawmiller has to take many decisions within a short time in processing raw material of highly hdterogeneous nature. Because position of first face determines the positron of subsequent faces or rectangles, the location of slabbing or opening face is a decisive factor in the improvement of recovery. It deserves mention of one of the most noteworthy technical advancements of this century in the United States- Best Opening Face (BOF), method of log breakdown for greater reocvery (Hallock and Lewis 1971). This method consists of fitting the maximum number of rectangles into a circle utilising computer technology to quickly calculate many possibilities and select the optimum. In spite of its significant possible role in improving lumber recovery in processing small diameter logs like rubberwood and coconutwood, it is probably difficult to justify the adoption of such computer techniques in small-scale sawmil is unless the capacity of certain mills is increased dramatically. For instance, it has been shown that as mill size increased the average lumber recovery factor also increased (Steel and Risbrudt 1985).

13.4 Problems of investment

In Kallayi and Baliapattanam, the logs are stored in water and are comparatively free from cracks and end splitting, resulting in high outturn. Here, maximum care has been taken to protect the logs from splitting or cracks because the timber merchants sell the sawn sizes to the consumer, therefore his profit depends upon the outturn. The picture is completely different in other places, where the logs are stored in open yard and no attention is paid to protect the logs frbm cracks and end splitting. One possible reason for this is that the timber merchants sell the logs to the consumers who saw it according to .their specifications. In this case, the timber merchants are interested only in sales of logs which enhance his profit.

About 85% of the sawmills in Kerala were started during the period of 1950-1980. This was considered as the golden period of sawmilling as raw material supply and capacity utilisation were high. Many sawmills are reported to have operated two shifts a day and earned profits many times higher than the original investment during this period. However, instead of pumping back a part of the profit for modernisation activities In the industry, many sawmill owners diverted the same to start other business or industry which gave additional income. At present, sawmilling is reduced to a secondary source of income to many sawmill owners. This has contributed much to the slow low modernisation activities and the present state of affair of the industry.

13.5 Integration

The concept of Integrating differnt industries offers more scope for greater utilisation of raw material/indutrial residues.As observed in some of the units, integration with plywood mills, furniture and joinery industries is in practicc.However,there is limited scope for the utilisation of sawmill'tresidues by pulpmilis in Kerala as the pulping units are not with in the easy reach of small–scale units owing to the non–economic transport of sawmill residues. Another industry that can utilise sawmill residues is particleboard and fibreboard mills which is yet to be developed in Kerala. However, further integration with other wood–based industries, such as furniture-making and joinery units can be strengthened.

14. Technological advancement

In industrialised countries, technological advancement took place in three phases (Fig. 16). The tirst phase of development up to the First World War period was moderately last, i.e lumber cutting technique evolved from the pracice or using broad axe to band saws through pit sawing, water-wheel powered sash or circular saws and then steam powered mills (Williston 1979). Thereafter significant changes did not occur up to the period of Second World War and it is only in 1950s and '60s that rapid advancement began with a trend being towards sophistication, automation, mechanisation and computerisation in order to meet the objective of higher productivity and greater lumber recovery.

According to Tilmann (1985), the objective of state-of-the-art sawmill is not to maximise lumber production but is to maximise cash flow generation through production and sale of lumber, pulp chips, particleboard furnish, fuel and speciality products. This is apparent in high speed small log handling mills which were introduced during 1960's in Scandinavian countries. Many of such mills adapted technology in (i) production chips for pulp and (ii) cants for lumber by introducing chipper canter machines (reducer band mills). One of' the developments in the United States during 1960's is the development of chipper headrig machines which improved productivity by virtue of their ability to process many pieces per minute. It did not become popular because of low lumber recovery especially in processing the logs with high taper, irregular cross section, sweep, crook etc. The most significant development was in the 1970's by evolving BOF method with the help of computers. The main unit operations where important technical advancements occurred are log scanning and merchandising, the headrig, edging, drying, planning and system controls (Tilman 1985).

In Kerala, early phase of technological advancement by way of imported technology before First World War period was remarkable because horizontal band saw was introduced to replace circular and frame saws (Anonymous 1906). The advantages recognised were:

(i) a great economy in labour, as the band saw required 3 men to work as against 6 with frame saws

(ii) less wood waste as compared to the earlier frame saws or circular saws

(iii) ecomomy of power to the extent of 25% as compared to circular saws.

However, **in** contrast to the rapid development in the western world, sawmill technology did not-make any headway in Kerala since 1950's. Despite the alarming situation of declining raw material supply, no effort has been made to improve the technology for higher sawn wood recovery by minimising the waste during conversion process. Even the newly built sawmills have only the traditional system with local made machineries of age-old design. One exception is, however, the Government owned units where improvements are under way as they could afford to use imported headrig saws and saw doctoring equipments with automatic operational system. In such units, usrng laser beam is also not uncommon in the determination of saw line for higher sawing accuracy.

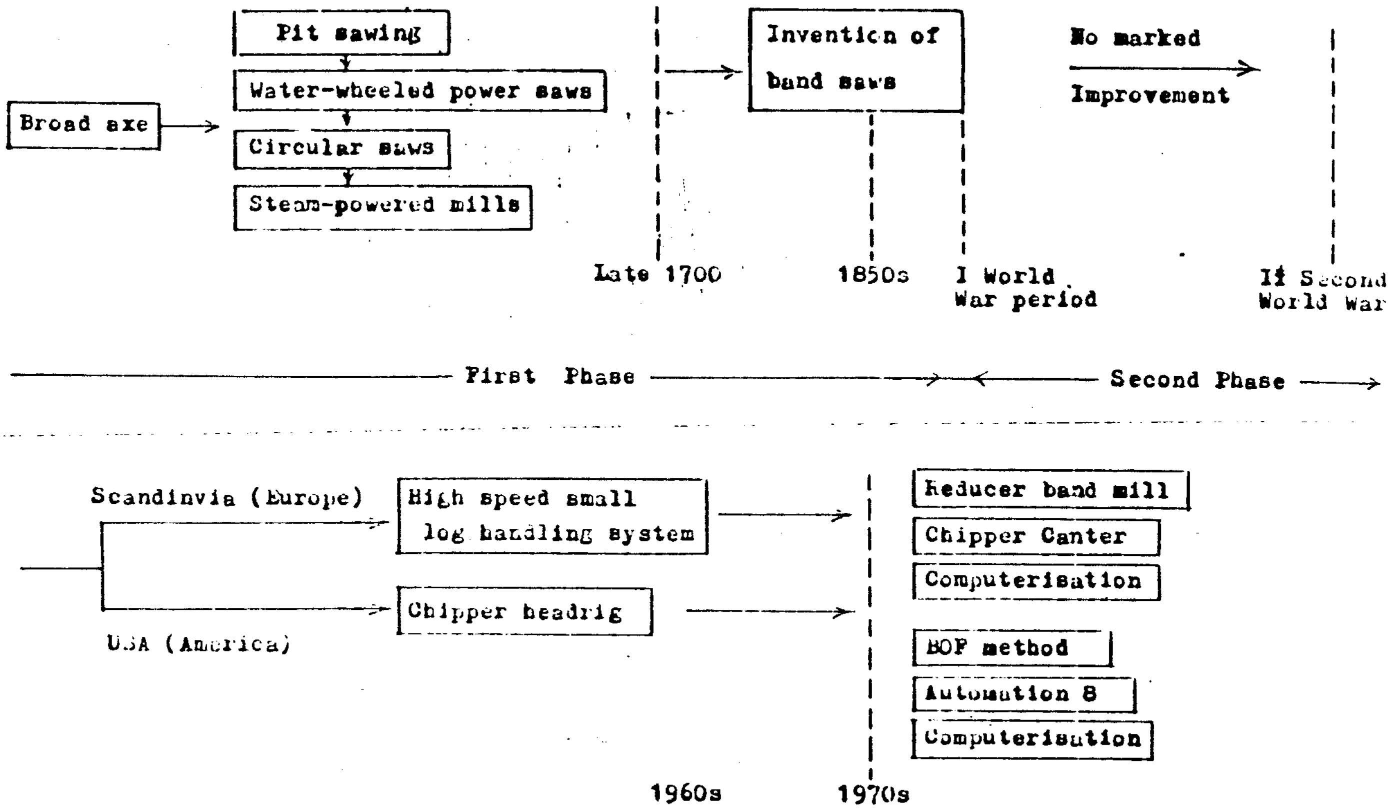


Fig. 16 Evolution of sawmilling technology in western world

15. Scope for modernisation (restructuring)

With the computerised automation of modern sawmiils in industrialised countries the technological gap between India and the western world is widening.Such capital-intensive techniques are not justifiable In Kerala for two reasons: Firstly,there **is** no guarantee of continuous raw material supply.Secondly, abandoning labour-intensive techniques may jeopardise the rural economy by reducing employment potential. However,the future demand for higher lumber quality and yield cannot be! overlooked in the interest of the developing economy of the state based on wood-based industries.Therefore the modernisation appears to be! possible only through the following means (Pelkonen **1986)**:

- Improve the skills and know-how at all organisation levels in the industry by providing training to use suitable machlnery,proper production flow and material handling as well as sound sawmilling practices

- Further integration of the units with joinery,furniture and decorative veneer industries.

15.1 Selection of machineries:

In order to improve the productivity, low-cost automation (LCA) may be introduced to some extent as an intermediate technology between highly capital-intensive and labour-intensive methods.For instance,it becomes necessary, atleast in some units,to convert the basic horizontal machines into semi or fully automated sawing machines and install lumber drying facility with low capital investments for better recovery and quality of sawn goods. The LCA technique may be effectively used with pneumatics and electricity (Brion 1983). Safety and human factors may also receive due consideration in this process of modernisation.

Equally important area in technological development is saw doctoring. Electronics and computer-assisted machines for greater precision and better quality'sharpening may not be appropriate for the small-scale units.However, the choice and quality of tho grinding wheel should be an important consideration.For conventional saw sharpening,grinding wheel with aluminium oxide (corundum) and cubic boron nitride may be used while mechanical sharpening with diamond-impregnated wheel is the only acceptable procedure for tungsten-carbide-tipped saws (Borstner 1985).Ceramic grinding wheels or those made of corundum and silicon grains are used for sharpening the saws of medium and high alloy steels.The size of grains depends on desired sharpening procedures.However, si1icon carbide grinding wheeis must be avoided for fine sharpening as they are suitable only for rough grinding (Ruzzenenti 1982). It is therefore, necessary to select the machnineries and tools at two levels(Pe1konen 1986): (i) simple machinery and equipment based on suitable hand operated tools for small mills (ii) a modern and fairly automated level, which enables the achievement of desirable quality, suitable for relatively large mills for instance e.g. government owned mills.

16. Shortage of raw materials: some remedial measures

The raw material shortage faced by this industry was due to decline in supply of timber, which was caused by large scale deforestation, and the increase in the number of sawmilling units. In this context, the following suggestions may be considered for solving the problem.

1. Indeed, a permanent solution to this problem rests upon augmenting the supply of timber internally.This could be attained in two ways. A massive tree planting particularly of fast growing species suitable for structural uses, in degraded and denuded lands in the state is imperative. There is a need to raise raw material by the mills for meeting their own requirements, preferably by establishment of a direct relationship between the mill and the individuals who can grow the timber with support of inputs including credit (Govt. of India, 1988).

2. The import of timber from foreign countries should be liberalised and encouraged. For increasing the import and equitable distribution of timber, the present system of import by the private agencies may be replaced by co- operative venture of sawmill owners.

3. Establishing new sawmills in the state may be until the situation of raw material supply improves considerably.

17. Summary and conclusions

Raw material shortage is a major problem and hence huge investment on modernisation will not be justified. However, no effort has been made to improve technology for higher sawn wood recovery by minimising the waste in conversion process, Because of raw material shortage, capacity utilisation accounts for only 53%. Thus a long term forestry strategy is essential for improving the supply of sawlogs in the state.

Size and integration which determine the level of capacity utilisation and income, play vital role in tho sawmilling Industry. Thus, broadening the capita1 base either by new investment or by change in tho ownership pattern is suggested.

Labour-intensive technology appears to be more appropriate for the sawmilling industry in Kerala. However, considering the future demand for quality lumber and improvement in productivity, introduction of simple tools of better design (in small units) and low-cost automation (in medium size units) are warranted. Future investment in machineries could be justified on two grounds: (i) In small *size* group the productivity of capital is high and (ii) In largo size groups, the capacity utilisation, income and profit are high. Thus, intoduction of low cost automation would be amply rewarded.

- Lack of knowledge, skill and training is another major problem in conversion technology. Owing to this, improper selection and maintenance of equipments and tools is common which greatly affects lumber recovery and grade. The low sawnwood outturn in the current practice is also attributable to both log degradation, due to biological and physical agents, and avaialability of relatively small diameter logs.

- Although log storage technology is not capital-intensive, sawmill owner has little interest in taking log protective measures owing to the present practice of contract sawing.

- Due to the lack of timber drying system and quality control as per the BSI specifications, sawn wood available in the market is of poor quality.

- Integration of sawmil1 units with other industries particularly joinery and furniture units needs to be strengthened for the improved utilization of sawmill

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APPENDIX

List of selected local manufacturers of sawmill machineries.

1. Bharath Engineering, Calicut.

2. Pavithra Industries, Calicut 673 003 (West Kallai).

3. St. Vincent Industries, Calicut.

4. New India, Bombay.

5. Molly Enterprises, Ollur 680 306, Trichur.

6. Padma Engineering, Perumbavoor

7. Srinivasa Industries, Cannanore.

8. Sharpex Engineering Works, Ahmedabad.