Small-scale harvesting operations of wood and non-wood forest products involving rural people

FAO FORESTRY PAPER
87

FOOD
AND
AGRICULTURE
ORGANIZATION
OF THE
UNITED NATIONS

Small-scale harvesting operations of wood and non-wood forest products involving rural people

by
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M-37
ISBN 92-5-102755-2

ACKNOWLEDGEMENTS

The Food and Agriculture Organization of the United Nations wishes to thank all those persons who, and institutions which have provided facilities, support and special assistance to the author in the preparation of the case studies, and in particular the following:

University of the Philippines at Los Baños, College of Forestry;

Universiti Pertanian Malaysia, Faculti Perhutanan;

Ecosystems Research and Development Bureau, Philippines.

SUMMARY

Part I of the report refers to the results of a case study on harvesting a bamboo plantation and a natural bamboo stand in the Philippines.

The harvesting operation was divided into work phases and elements. In the bamboo plantation, three work phases were defined; pole preparation, minor transport and major transport. In the natural bamboo stand, pole preparation and minor transport were studied.

In the pole preparation phase, in both cases, the traditional handtools, bolos, were used. Minor transport in the bamboo plantation was carried out manually. This work phase was the most tiring and a production bottleneck. Major transport was carried out with a tractor and trailer. The trailer was locally made. In the natural bamboo stand carabao and sled were employed for minor transport.

Time and work studies were carried out on the harvesting work phases. Time and production standards of each harvesting phase were calculated and are presented in this report. General figures on the establishment cost for the bamboo plantation are also presented.

Discussion on the participation of rural people in bamboo harvesting has also been included.

Part II of the report refers to the results of a case study on the production of firewood from the bark of dipterocarp species in the Philippines.

Bark from dipterocarp logs is a good potential source for fuelwood. Bark firewood production is a profitable small-scale forest-based enterprise for rural communities situated close to forest industries in the Philippines, which can serve as an example to other countries.

The study dealt with the identification of work phases and the market outlets for the bark firewood enterprise.

Three bark firewood enterprises that strip the bark from industrial logs loaded on trucks were visited, observed and studied.

Seven work phases were observed in the production of two types of firewood, namely: thin splits (hinibis) for household use and wide splits (nilagpad) for restaurants and bakeries.

Part III of the report refers to the results of a case study on a harvesting operation in a mangrove forest in Malaysia.

Two harvesting operations were studied: thinning and final clear felling. Pole preparation and minor transport were the two work phases identified in thinning. Pole preparation was done with an axe and minor transport was manual. In the final clear felling, billet preparation and minor transport were the work phases identified. Billet preparation is done with a chainsaw for felling, bucking and delimbing. A locally made mallet was used for debarking. Minor transport of the billets is done with a locally made wooden wheelbarrow driven manually on a wood plank walk.

Time and work studies were carried out for each work phase. Time and production standards were calculated and are presented in the report.

The Matang mangrove forest silvicultural system is briefly discussed. Harvesting techniques, work organization, equipment and tools used are described in the report.

The involvement of the rural people in the harvesting of mangrove forests, in general, is discussed.

SYMBOLS AND EXCHANGE RATES

SYMBOLS

cm = centimeter

m^3 = cubic metre

ha = hectare

hr = hour

km = kilometer

m = metre

% = percent

t = ton

M$ = Ringgit

P = Peso

US$ = US dollar

EXCHANGE RATES

1 US$ = M$ 2.51 (March, 1988)

1 US$ = P 20.48 (August, 1987)

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INTRODUCTION

In the last few years in many industrialized and developing countries a significant change has taken place in the role of forestry vis-à-vis the public at the country or local level insofar as utilization patterns, formulation of forest policies and future action programmes are concerned. In most countries in the past, forests were primarily managed to satisfy the needs of large forest industries and only in recent years has there been an increasing awareness of the importance of the role of forestry and harvesting for the supply of raw materials to smaller mills thus enabling an increased distribution of the benefits obtainable from the forests.

It now seems that in many industrialized and developing countries the production of wood for energy (fuelwood, charcoal, gas from wood) as well as for small-scale forest industries and cheap building material, has become more and more important.

Highly mechanized, capital-intensive harvesting systems do not allow the participation of the rural people who live within or in the vicinity of the forest. It is thus important to introduce small-scale forest harvesting systems that rely on basic or intermediate technology.

Non-wood forest products can also have an economic value for the rural people. Such is the case of bamboo, and that of bark for firewood.

The specific objective of this study has been to investigate small-scale forest harvesting operations; to develop time and production standards and to recommend improvements in work phases and tools. It is hoped that the case studies will prove useful for countries where similar conditions exist.

The study was carried out under the André Mayer Research Fellowship Programme 1986/87 of the Food and Agriculture Organization of the United Nations. The programme, instituted for the furtherance of advanced research, was first established as a regular activity of FAO in 1956. The name "André Mayer" was associated with these research fellowships in memory of a distinguished man who, for many years, until his death in 1956, was a source of inspiration and guidance to FAO.

This research project was awarded to Mr. Virgilio dela Cruz, from the Philippines, who undertook the study in the Philippines and in Malaysia under the guidance of the University of the Philippines at Los Baños and the Universiti Pertanian Malaysia, both of which acted as host institutions. The technical leadership of the research project was provided by the Forest Logging and Transport Branch of the Forest Industries Division of FAO.

The study has been divided into three parts. Part I deals with bamboo harvesting, part II with the production firewood from dipterocarp bark and part III with the harvesting of mangroves. Parts I and II were carried out in the Philippines while Part III took place in Malaysia.

PART I

HARVESTING A BAMBOO PLANTATION AND A NATURAL BAMBOO STAND

BACKGROUND

Bamboo has many uses. In rural areas it is extensively used for low-cost housing. About 80% of the total use of bamboo in the Philippines is for house construction. Bamboo is used for house posts, joints, beams and even for fastening nails. It can also be used for roofing, house walls, partitions, ceilings and floors.

Handicraft industries also twine bamboo into fruit trays, lampshades, baskets, ashtrays, flower bases, brooches, fans, picture frames, jewelry boxes, among other items. Bamboo is also used for furniture such as tables, beds, chairs and cabinets. In the fishing sector, bamboo is an indispensable item for the common fisherman's raft, fish traps, fishing rods and fish pens.

The banana industries in Davao prefer bamboo poles as banana props rather than wooden props (see Figure 1). Even the world of music has found use for bamboo. Musical instruments such as horns, clarinets, flutes and xylophones have parts made of bamboo. The world famous organ at the Roman Catholic Church of Las Pinas, Metro Manila, is made mostly of bamboo.

In other countries, bamboo is an important source of long fibre for pulp and paper manufacture. India, for instance, is a known leader among Asian countries in the manufacture of paper from bamboo. Many artful stationeries in Japan are made out of bamboo fibre. Bamboo is also used as food and medicine. Young bamboo shoots are made into pickles, salad and other delicacies.

Bamboo's versatility is partly due to the high number of species. In the Philippines alone, 54 species of bamboo have been recorded. Only eight of the erect species are, however, considered commercial: *Bambusa blumeana* Schultes f., *Bambusa vulgaris* Schrad ex. Wendl., *Dendrocalamus merrillianus* Elm, *Dendrocalamus latiflorus* Munro, *Schizostachyum lumampao* (Blanco) Merr., *Schizostachyum lima* (Blanco) Merr., *Gigantochloa aspera* Kurz, and *Gigantochloa levis* (Blanco) Merr. (1).

STATE OF THE ART

Bamboo is a perennial plant and belongs to the Graminae family. It is characterized for having a woody, usually hollow stem with nodes. The stem is commonly called culm. The growing habits of bamboos are either monopodial (single-stemmed) or polypodial (densely-stemmed). A clump is a unit of densely-stemmed bamboos. In the utilization aspect, a harvested culm, crosscut to a desired length, or even in culm length, is referred to as pole.

Figure 1

Bamboo poles are used for banana props

Harvesting bamboo induces growth. The production of the clump can be improved by cutting undesirable and crowded culms.

When culms have more space, the quality of bamboo stands is improved (4). It has been demonstrated in Sri Lanka that removal of dead and deformed culms induces the development of the best culms (11). In Indonesia, bamboo harvesting is carried out by selective cutting (12). This is done by choosing 3 to 4-year old culms inside the clump. The removal of spiny branches of Bambusa blumeana Schultes f. in and around the lower portion of the clumps and high stumps, and the cutting of deformed and over mature culms during harvesting increase culm production. A study on this showed that treated clumps produced an average of 163 culms compared to 86 culms of the untreated clumps (9). The cutting of spines also reduces the number of deformed culms because shoots can easily emerge (7). Moreover, the removal of bamboo rhizomes gives a better bamboo shoot production. However, one-year old culms should not be harvested so as to maintain the outgrowth of the shoots. Pruning of one-year old Dendrocalamus merrillianus Elm. ensures durability and induces development of young shoots (5).

Short harvesting cycles of bamboo is an advantage. When bamboos are left uncut beyond maturity they become less vigorous, and the quality decreases. Hence, the growth of young shoots is inhibited (10).

The clump-forming bamboo culms should be cut at about 15 to 30 cm above the ground, just above a node, in order not to leave receptacles in which rainwater can be collected. Cutting the culm too high results in unnecessary waste leads to clump congestion and difficulty in harvesting (9). Cutting of thinner culms between nodes should also be avoided as the end of the culm can split. All branches must be cut close to the stem (3).

Fellers can cut Schizostachyum lumampao (Blanco) Merr., and Dendrocalamus merrillianus Elm. close to the ground. Spiny bamboo is usually cut about 2 or 3 m above the ground, thus leaving the best portion of the culm. The dense growth of spiny branches hinders the cutting of spiny bamboo closer to the ground.

The harvesting and transport of bamboo is generally carried out by manual means and requires skill, considerable patience and energy. Cutting is generally done by using a small axe, machete (bolo) or bill hook. For monopodial bamboos, bowsaws or saws can also be used. In India, an attempt was made to use a chainsaw, but with little success (2). Minor transport of bamboo is sometimes mechanized, however, water buffaloes (carabaos) are often used to transport bamboo from the clump site to the roadside. Manual skidding of bamboo is also common but is normally used for short distance up to 200-300 m.

The subsequent major transportation of bamboo is done with small trucks, agricultural tractors and one or two axle trailers, or with water buffaloes pulling small wagons. River rafting is used for long distance transport of bamboo (6).

DESCRIPTION OF THE STUDY AREA

The studies were undertaken in a bamboo plantation and in a natural bamboo stand.

Bamboo plantation

The harvesting study was conducted at the bamboo plantation of the Davao Fruit Corporation in Compostela, Davao del Norte. The plantation, bisected by the Montevista-Compostela road was established in 1978 and has an area of 125 ha (see Figure 2).

Figure 2

11 year old bamboo plantation

The planted species is Dendrocalamus latiflorus Munro. At the time of the study, each clump had an average of 11 culms and 3 young shoots. With a 5 x 5 m spacing between clumps, one hectare had 400 clumps with an average of 4 400 culms and 1 200 young shoots.

The bamboo plantation is situated on rolling to rough terrain. The rainfall is evenly distributed throughout the year with very slight dry periods from March to June.

The total road length in the plantation is 5.2 km. The road density is 43 m/ha, while the road width is 5 m. On the rolling terrain, a gravelled main road and feeder roads were constructed (see Figure 3). In the interior and rough terrain only foot trails and excavated steps were constructed (see Figures 4 and 5). Road maintenance involves patching of holes and gullies and drainage improvement, when the need arises.

For the first harvest at 5 years, it was estimated that a single clump yields a maximum of 80 poles, with an average of 20 to 30 poles or 10 000 poles/ha. However, the succeeding harvest was estimated to have an average yield of 6 600 poles/ha per year. The average culm diameter at 30 cm was about 7 cm and the total height was 15 m on average.

During the study some general information was collected on establishment cost of the bamboo plantation covering site preparation, planting material (rhizome) collection, planting and weeding.

Site preparation took 7 man-days per hectare. Planting material collection and planting both have an average production of 60 rhizomes per man-day. One hectare requires 400 rhizomes and thus 13 man-days are required for the planting material collection and planting.

Weeding is done three times during the first year. Each weeding requires 3 man-days per hectare.

The labour cost per man-day is P 45.00.

The total establishment cost per hectare of the bamboo plantation (labour only) is as follows:

Site preparation:	7 x P 45 = P	315
Planting material collection and planting:	13 x P 45 = P	585
Weeding:	3 x 3 x P 45 = P	405
Total establishment cost	= P	1 305

Figure 3

Main road in the bamboo plantation

Figure 4

Foot trail in the interior bamboo plantation

Natural bamboo stand

The harvesting study of a natural bamboo stand was undertaken in Kidapawan, Cotabato. The natural bamboo stand is situated on privately owned land along a river bank. There is an earth road close to the river which has been built by the municipality.

In the area, bamboo is not only important as a commercial product, it also prevents river bank erosion. Furthermore, it provides shade to the rural people who wash clothes at the river side. For the agricultural crops planted nearby, bamboo serves as a live fence and a protection against the wind.

The owner of the natural bamboo stand is a farmer. He makes a living by growing and selling agricultural crops such as vegetables, bananas and coconuts. The bamboo poles he sells represent an additional income to the household.

Figure 5

Excavated steps on steep slopes

The clump base of the harvested specie, Bambusa blumeana Schultes f., is characterized by having dense branches entangled with one another and forming an impenetrable shield up to 3 m from the ground (see Figure 6). The average culm diameter measured at 3 m above the ground due to the congested clump base was 11 cm and the average height was 20 m. The estimated age of the clumps was 30 years.

DESCRIPTION OF EQUIPMENT AND TOOLS

The equipment and tools used during the study are as follows:

Bamboo plantation

For cutting three different kinds of bolos were used (see Figure 7). One is curved at the tip, another is straight with an equal width, while the third is at its widest at the far mid-point. The bolos were locally made from truck springs. During the study, a Sandvik pruning saw was introduced and tested.

Figure 6

Bambusa blumeana Schultes f. congested clump

The minor transport was carried out manually. A six-cylinder Ford farm tractor and a trailer was used for the major transport. The platform of the doubled axled and four-wheeled trailer measured 2 x 6 m. The trailer was made locally. The axles were located at the end of the trailer for greater maneuverability (see Figure 8).

Natural bamboo stand

The bolo was used for cutting the culms. No accessory tools were used. Minor transport from the clump site to the roadside over an average distance of 175 m was carried out by carabao with a sled (see Figure 9). Motor vehicles were used for major transport of the bamboo poles.

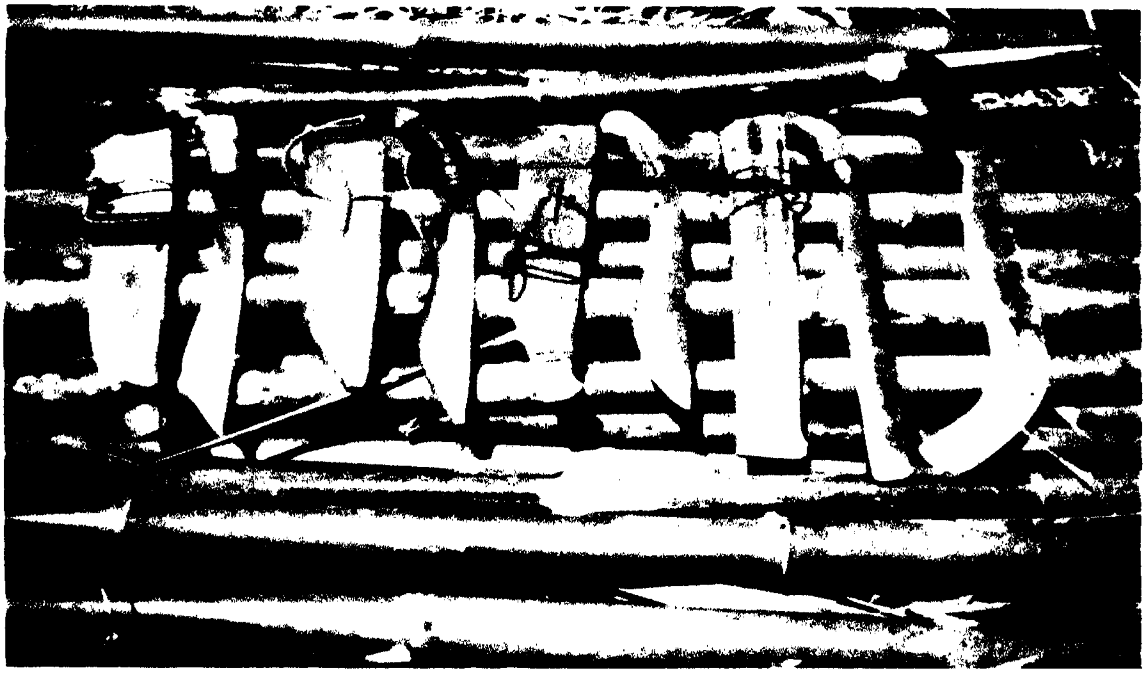

Figure 7

A variety of bolos is used for bamboo cutting

Figure 8

A trailer was used in the major transport
of bamboo plantation poles

Figure 9

A carabao and a sled were used for the minor transport of the natural bamboo stand poles

WORK ORGANIZATION

The work organization refers to the procedure currently used and no changes were introduced.

Bamboo plantation

The bamboo plantation is headed by a project manager. The plantation is divided into blocks and there is a supervisor responsible for each one. Under the unit supervisors, there are two groups of labourers; the regular maintenance group and the contractual harvesting groups. Directly under the project manager is the major transport group.

The regular maintenance groups carry out the establishment and tending of the plantations, road maintenance and foot trail construction. The maintenance groups are paid on a daily basis.

The contractual harvesting groups are in charge of the preparation of poles and minor transport. These groups are composed of families and thus, both sexes and all ages are represented. They are paid by piece rate but a minumum production quota is fixed per day. Close to the roadside, the quota is 75 poles per day for cutting, manual transport and piling at the roadside. In interior areas, the cutting quota is 45 poles.

Minor transport and piling at the roadside, which is separately done and paid for, has no quota.

The contractual harvesting groups are paid by their production in poles. For the pole preparation work phase, the payment is P 0.34 per pole while in the minor transport work phase, the payment is P 0.50 per pole. The two workers who load and unload the poles in the major transport phase are paid P 0.07 per pole delivered to the banana plantation.

The labourers start work as early as 6:30 am; they bring a packed breakfast with them, which they eat on the worksite at around 8:00 am. Usually, the production quota is met before noon and the labourers are free to leave if they wish. Effective working hours per day are only 2 to 3 hours in the interior areas, but longer close to the roadside.

The workers income per day, meeting their minimum production quota, is P 25 for the pole preparation work phase. In minor transport, the production standard per day was 48 poles, earning P 24 per day. For a single trip per day in major transport each worker who loads and unloads the poles earns P 31 per day.

After their work in the bamboo plantation, usually in the afternoon, the workers tend their piece of land. They grow agricultural crops for their consumption and for sale. They also raise livestock, cattle, goats and chickens. Sometimes, they fish in the nearby river.

Natural bamboo stand

The buyer is in charge of harvesting and transporting the bamboo poles. Neighbours usually help the buyer to do the cutting and minor transport. The harvested bamboo is commonly used for house construction in the region.

HARVESTING TECHNIQUES

Harvesting is mostly manual and involves rural people.

Bamboo plantation

The first harvest is carried out during the third to the fifth year of the plantation. Harvesting intensity is 3 to 4 times a year per clump close to the roadside, and 2 to 3 times a year per clump in the interior. Due to easiness of extraction and the demand for poles, roadside areas up to a minor transport of around 50 m are more frequently harvested than interior areas. Harvesting is a year round operation.

The harvesting scheme which assures the continuous yield of bamboo culms is selective cutting. The matured culms of 1 to 1.5 years are cut first leaving the younger culms for future harvests. The larger immature culms support and protect the smaller culms.

The matured culms are cut at approximately 30 cm above ground level (see Figure 10). The bamboo is polypodial or clump forming. More often than not, cut culms hang on to the standing culms, therefore, they need to be separated and pulled away for debranching and crosscutting (see Figure 11). The culm is crosscut into 5 m poles as specified for the banana props (see Figure 12). Poles are then piled at the clumpsite, counted and quality checked by the supervisor before the minor transport. It was estimated that 50 poles were equivalent to one cubic metre stacked volume.

Figure 10

The poles were felled with bolos

Figure 11

Lodged poles are pulled out manually

The minor transport consists of carrying the poles on the shoulder from the clump sites to the roadside. The minor transport distance is sometimes up to one kilometer. An average bundle of 5 poles is carried to the roadside by the cutter or by the workers who only do this work.

The major transport consists of hauling the poles from the roadside to the delivery points. From March to June, which are the peak months of banana fruiting, the delivery point is a central landing from which the banana plantation workers further distribute the poles. During the rest of the year, hauling is carried out directly to delivery points at the banana plantation. There is no hauling on rainy days in order not to damage the roads. The average major transport distance is 6 km.

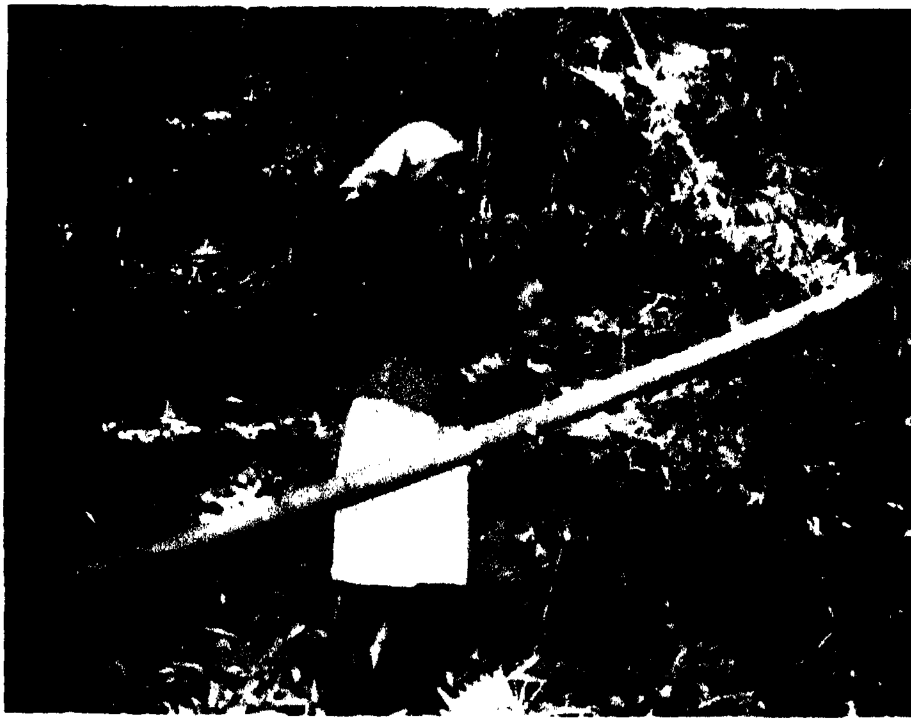

Figure 12

Debranching a pole in the bamboo plantation

Loading and unloading is carried out by the same crew of two men. To properly secure the pole load, a rope is tied across the trailer width to the two vertical stakes. Both men unload the poles simultaneously from each side of the trailer. When the unloading is along the roadsides of the banana plantation, 200 poles are unloaded at each point. The last batch of poles is unloaded by unfastening the stakes and rolling the poles off the trailer.

Natural bamboo stand

Harvesting is carried out only when there is a customer available. There is no definite schedule or period for harvesting. However, it has been noted that buyers usually come during the dry season because the roads are in better condition and it is the period for house repairs and constructions. Bamboo cut during the dry season is also more durable, due to less starch content.

The buyer cuts the good quality culms located on the outer part of the clump (see Figure 13). Clearing of branches at the clump base is not done, so the cutting height is high, approximately 3 m. The culms are also very close at the base. According to the owner, the congested base protects the young culms. The bolo is used for cutting the culms which are not crosscut. It was estimated that 30 poles were equivalent to one cubic metre stacked volume.

Figure 13

Cutting of a Bambusa blumeana Schultes f. congested clump

Minor transport is carried out with carabao (water buffalo) and sled. The carabao is a popular agricultural working animal in the Philippines. Before the introduction of mechanized logging, carabao was also used in skidding small size timber in the natural forests and is still used today in plantation forests. The carabao is very adaptable, easily trained and very useful for skidding where roads are not available and on muddy terrain.

In minor transport, the carabao is equipped with a wooden sled. A yoke is placed over the carabao's neck where the sled is fastened. The yoke is made from a bent bamboo culm or carved from wood. The sled is made of two poles of bamboo or small trees with branch stubs at the end to fix a cross member.

TIME AND WORK STUDY

Data gathering in the bamboo plantation and in the natural bamboo stand took place during August/September 1987. The operations were initially intensively observed to define the work phases and the corresponding elements.

Time studies were carried out on work phases using the continuous timing method. Time was recorded with a stopwatch graduated in 60 seconds with a 30 minute graduation in the inset. Distance was measured with a 50 m tape and production was recorded by the number of poles. Unproductive long delays such as rests, drinking water and eating breakfast were also recorded.

The calculation of the time and production of the work phases and elements which are not affected by the distance is by averaging. The total sum of all time observations of the phase or element is divided by the total number of observations. The work phase and elements not affected by the distance are pole preparation, bundling, loading and unloading.

On the other hand, the calculation of the time and production of the work elements affected by the distance is by calculating the time and production per unit distance. This is done by dividing the total time of all the observations for the element by the total distance of all the observations. The elements affected by the distance are unloaded trip and loaded trip.

Pole preparation

In the bamboo plantation, 8 workers (including both women and men) using the conventional bolo were observed. In the case of the newly introduced pruning saw the workers were allowed to practice for a day before time data was recorded. Two workers were observed using the pruning saw. The pole preparation phase consisted of clearing the clump, cutting, debranching and piling the poles at the clump site.

Minor transport

In the bamboo plantation, 10 workers (including both men and women) were observed in the minor transport of poles from the clumpsite to the roadside, which was carried out manually. The poles were bundled using nylon rope, bamboo splits, rattan and vines.

The minor transport phase in the bamboo plantation was divided into four work elements: unloaded trip, bundling, loaded trip and unbundling.

1. The unloaded trip starts when the worker begins to walk to the clumpsite and ends with his arrival.

2. The bundling starts when the workers arrive at the clumpsite to pick up a number of poles from the stock pile for bundling and ends when the worker starts to carry the bundle. The poles are tied at the front and back ends (see Figure 14).

3. The loaded trip begins when the worker starts to carry the bundle on his shoulder and ends when the bundle of poles is put down at the roadside pile (see Figure 15).

In the natural bamboo stand, the minor transport was carried out by the carabao and sled.

The minor transport phase in the natural bamboo stand was divided into four work elements: unloaded trip, loading, loaded trip and unloading.

1. The unloaded trip starts when the carabao with sled begins to move to the clumpsite and ends on its arrival.

2. The loading starts upon the arrival of the carabao. The sled is unfastened and poles are loaded and the sled is fastened to the carabao. The element ends when the carabao starts to move to the roadside (see Figure 16).

3. The loaded trip starts when the carabao starts to move to the roadside and ends upon the arrival (see Figure 17).

4. The unloading starts upon the arrival at the roadside and ends when the load has been unloaded and the rope tied securely onto the sled (see Figure 18).

Figure 14

Bundling of bamboo plantation poles

Figure 15

The minor transport of bamboo plantation poles

Figure 16

The natural bamboo stand poles are loaded in culm lengths onto the sled

Figure 17

Carabao skidding of the natural bamboo stand poles

Figure 18

Unloading the sled

Major transport

Major transport in the bamboo plantation is carried out by a farm tractor with a two-axle trailer manned by one tractor operator and two helpers who load and unload the poles.

The major transport phase in the bamboo plantation was divided into four elements: unloaded trip, loading, loaded trip and unloading.

1. The unloaded trip starts when the farm tractor leaves the banana plantation and ends when the trailer is positioned at the first roadside pole pile for loading.

2. Loading starts when the first pole is picked up to be placed on to the trailer and ends when the trailer is fully loaded. The movement of the tractor from one pile to another was included in the loading element (see Figure 19).

3. The loaded trip starts when the farm tractor leaves to deliver the poles to the banana plantation and ends when the tractor stops at the first unloading point.

4. The unloading starts when the load is hauled down at the first unloading point and ends when the load is fully unloaded at the last unloading point. Travel time from one unloading point to another was included in the unloading element.

No major transport was carried out in the natural bamboo stand during the study period.

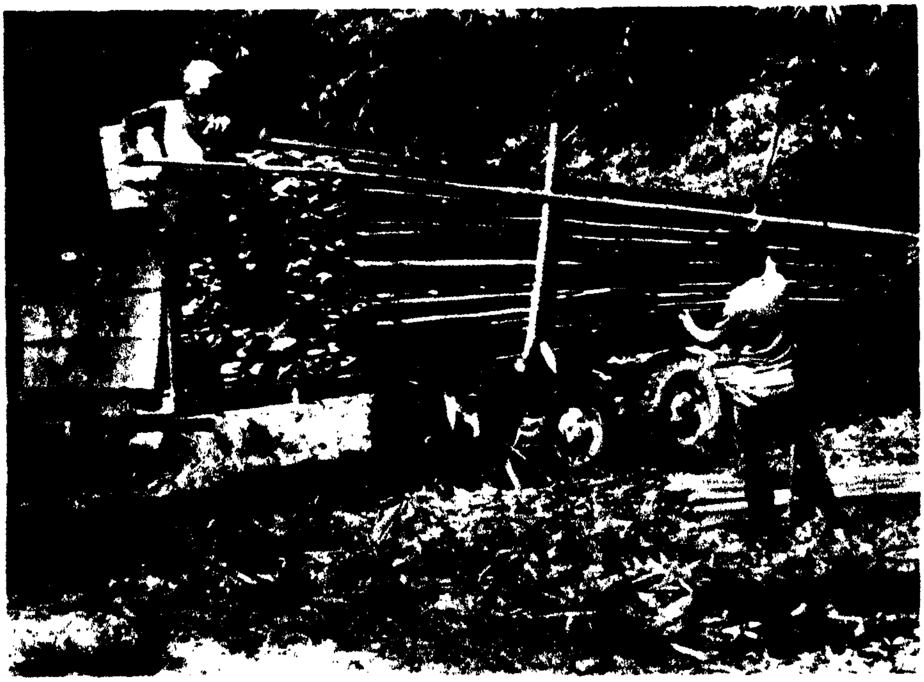

Figure 19

Loading the bamboo plantation poles onto the trailer

RESULTS

The results of the study refer to the time and production standards.

Time standards: Bamboo plantation

Time standards were calculated for pole preparation, minor transport and major transport.

Pole preparation

The time standard for pole preparation were calculated by dividing the total effective time (without delay) by the total number of poles produced during that time.

There were two cutting tools used, the bolo and the pruning saw.

Of a total conversion of 41 culms with the bolo, a total number of 66 poles were produced in 181 effective minutes, thus, the time standard is:

$$PP_t \text{ (bolo)} = \frac{181}{66} = 2.7 \text{ minutes/pole}$$

Of a total conversion of 39 culms with the pruning saw, a total number of 66 poles were produced in 141 effective minutes, thus, the time standard is:

$$PP_t \text{ (pruning saw)} = \frac{141}{66} = 2.1 \text{ minutes/pole}$$

Minor transport

Minor transport was carried out manually over an average distance of 235 m. The time consumption was determined by studying 41 round trips. The total one-way distance was 9 625 m.

Unloaded trip time

The total unloaded trip time was 227 minutes and the unloaded trip time per metre is:

$$ULT_t = \frac{227}{9625} = 0.024 \text{ minutes/m}$$

The equation for the unloaded trip time would be:

$$ULT_t = 0.024\ X$$

where:

ULT_t = unloaded trip time, in minutes

X = distance, in metres.

Bundling time

The total bundling time for 41 bundles was 161 minutes, thus, the time standard in bundling is as follows:

$$B_t = \frac{161}{41} = 3.9 \text{ minutes/bundle}$$

Loaded trip time

The total loaded trip time was 237 minutes and the loaded trip time per metre is:

$$LT_t = \frac{237}{9625} = 0.025 \text{ minutes/m}$$

The equation for the loaded trip time would be:

$$LT_t = 0.025\ X$$

where:

LT_t = loaded trip time, in minutes

X = distance, in metres.

Unbundling time

The total unbundling time for 41 bundles was 17 minutes, thus the time standard in unbundling is as follows:

$$UB_t = \frac{17}{41} = 0.4 \text{ minutes/bundle}$$

Minor transport round trip time

The minor transport round trip time is the sum of the elements. The equation would be:

$$MIT_t = 3.9 + 0.4 + 0.024X + 0.025X$$

$$= 4.3 + 0.049X$$

where:

MIT_t = minor transport round trip time, in minutes

X = transport distance, one-way, in metres.

Major transport

Travel speed was recorded with the speedometer. The average loading and unloading time per load was calculated by multiplying the average consumption per pole by the average number of poles per load and by adding the average travel time in every loading and unloading point.

Unloaded trip time

The recorded speed for the unloaded trip was 15 km/hr. By dividing 60 minutes by the speed, one arrives at the equation of the travel time standard, thus:

$$ULT_t = \frac{60}{15}X = 4X$$

where:

ULT_t = unloaded trip time, in minutes

X = distance, in kilometers.

Loading time

The loading time of 838 poles was 126 minutes, thus, the time in loading one pole is 0.15 minutes. The loading time of an average load of 900 poles is 135 minutes. The average travel time between loading points was 62 minutes. The loading time standard is given by:

$$L_t = 135 + 62 = 197 \text{ minutes/load}$$

Loaded trip time

The recorded speed for the loaded trip is also 15 km/hr. Dividing 60 minutes by the speed gives the equation of the loaded trip time, thus:

$$Lt_t = \frac{60}{15}X = 4X$$

where:

Lt_t = loaded trip time, in minutes

X = distance, in kilometers

Unloading time

The unloading time of 1,788 poles was 37 minutes, thus, the time in unloading one pole is 0.02 minutes. The unloading time for an average load of 900 poles is 18 minutes. The average travel time between unloading points was 50 minutes. The unloading time standard is given by:

$$Ul_t = 18 + 50 = 68 \text{ minutes/load}$$

Major transport round trip time

The major transport round trip time is the sum of the elements. The equation would be:

$$MAT_t = 197 + 68 + 4X + 4X$$

$$= 265 + 8X$$

where:

MAT_t = major transport round trip time, in minutes

X = distance, in kilometers

<u>Time standards: Natural bamboo stand</u>

Time standards were calculated for pole preparation and minor transport.

<u>Pole preparation</u>

Of a total conversion of 41 culms, a total number of 41 poles were produced in 700 effective minutes thus, the time standard is:

$$PP_t = \frac{700}{41} = 17.1 \text{ minutes/pole}$$

<u>Minor transport</u>

A carabao with a sled was used for the minor transport. There were 9 round trips studied and the total distance was 1575 m which gives an average transport distance of 175 m.

Unloaded trip time

The total unloaded trip time was 27 minutes and the unloaded trip time per metre is:

$$ULT_t = \frac{27}{1575} = 0.017 \text{ minutes/m}$$

The equation for the unloaded trip time would be:

$$ULT_t = 0.017\ X$$

where:

ULT_t = unloaded trip time, in minutes

X = distance, in metres.

Loading time

The total loading time for the 9 loads was 55 minutes, thus, the time standard in unloading is as follows:

$$L_t = \frac{55}{9} = 6.1 \text{ minutes/load}$$

Loaded trip time

The total loaded trip time was 33 minutes and unloaded trip time per metre is:

$$LT_t = \frac{33}{1575} = 0.02 \text{ minutes/m}$$

The equation for the loaded trip time would be:

$$LT_t = 0.02\ X$$

where:

LT_t = loaded trip time, in minutes

X = distance, in metres

Unloading time

The total unloading time for the 9 loads was 13 minutes, thus, the time standard in unloading is as follows:

$$UL_t = \frac{13}{9} = 1.4 \text{ minutes/load}$$

Minor transport round trip time

The minor transport round trip time is the sum of the elements. The equation would be:

$$MIT_t = 6.1 + 1.4 + 0.017X + 0.02X$$

$$= 7.5 + 0.037X$$

where:

MIT_t = minor transport round time, in minutes

X = distance, in metres.

Production standards: Bamboo plantation

Production standards were calculated for pole preparation, minor transport and major transport.

Pole preparation

Pole preparation production standard in poles per hour was calculated by dividing 60 minutes by the pole preparation time standard. Pole preparation production standard is as follows:

$$PP_p \text{ (bolo)} = \frac{60}{2.7} = 22 \text{ poles/hr}$$

$$PP_p \text{ (pruning saw)} = \frac{60}{2.1} = 29 \text{ poles/hr}$$

Minor transport

The minor transport production standard was calculated by dividing 60 minutes by the minor transport round trip time, which results in the number of round trips per hour. By multiplying the number of round trips per hour by the average number of poles per bundle or load, results in the minor transport production standard.

The average number of poles per bundle was 5, thus the minor transport production standard equation is as follows:

$$MIT_p = \frac{60 \text{ X } 5}{4.3 + 0.049X}$$

where:

MIT_p = minor transport production standard, in poles/manhour

X = distance, in metres.

Table 1 shows the calculated minor transport production standards by the distance.

Major transport

The major transport production standard was calculated by the same procedure as in the minor transport.

The average number of poles per load was 900, thus the major transport production standard equation is as follows:

$$MAT_p = \frac{60 \text{ x } 900}{265 + 8X}$$

where:

MAT_p = major transport production standard, in poles/manhour

X = distance, in kilometers

Table 2 shows the calculated major transport production standards by the distance.

Table 1

Bamboo plantation minor transport production standards

Distance (m)	Trips per hour	Production (poles/manhour)
100	6.5	33
200	4.3	21
300	3.1	16
400	2.5	13
500	2.1	10
600	1.8	9
700	1.6	8
800	1.4	7
1000	1.1	6

Table 2

Bamboo plantation major transport production standards

Distance (km)	Trips per hour	Production (poles/hour)
1	0.22	198
2	0.21	192
3	0.21	187
4	0.20	182
5	0.20	177
6	0.19	173

Production standards: Natural bamboo stand

Production standards were calculated for pole preparation and minor transport.

Pole preparation

Pole preparation production standard in poles per manhour was calculated by the same procedure as in the bamboo plantation, thus:

$$PP_p = \frac{60}{17.1} = 4 \text{ poles/hr}$$

Minor transport

The minor transport production standard was calculated also by the same procedure as in the bamboo plantation. The average number of poles per load is 5, thus:

$$MIT_p - \frac{60 \times 5}{7.5 + 0.037X}$$

where:

MIT_p = minor transport production standard, in poles/manhour

X = distance, in metres.

Table 3 shows the calculated minor transport production standard by the distance.

Table 3

Natural bamboo stand minor transport production standard

Distance (m)	Trips per hour	Production (poles/manhour)
100	5.4	27
200	4.0	20
300	3.2	16
400	2.7	13

CONCLUSIONS AND RECOMMENDATIONS

Bamboo, due to its many uses, is a very important commodity for the rural people in the Asia/Pacific region and other regions of the world. Bamboo is used for house construction, furniture, handicrafts, musical instruments, food and for several other items of every day use.

Mostly, bamboo grows naturally on the river banks, however, it can be raised into plantations. In both cases, the rural people receive benefits from bamboo in terms of its uses and income. The natural bamboo stands control river bank erosion and enhance the continuous water flow. Bamboo poles are sold to the handicraft industry, fishermen and to individual people for house construction. Bamboo plantations offer a steady income for its establishment and harvesting operations.

There are other non-wood products which could be a good source of income for the rural people. These non-wood products are mostly used for furniture and handicraft some of which offer a good market worldwide. Rattan is a good example.

In the Philippines, bamboo natural stand are diminishing and there is an urgent need to establish plantations. One main reason is to cater the demand for bamboo poles, especially for house construction and for banana props. Apart from the commercial uses of bamboo, it is also a good crop for watershed management. Bamboo has numerous deep roots to hold the soil and water. Harvesting bamboos in the watershed areas will not relatively affect the purpose of holding the soil and water. In this regard, it is recommended that the establishment of bamboo plantations be incorporated into social forestry and reforestation programmes of the government. A communal bamboo forest on denunded forest land near the community could be initiated by the rural people themselves, or a civic organization to be established and harvested by the rural people.

Harvesting of bamboo requires skill, technique and proper tools. In the study, cutting with the pruning saw gives more production than the conventional bolo. However, the pruning saw is only used for cutting and the bolo for debranching and crosscutting. Although the pruning saw could also be used for crosscutting, the bolo, in two or three strokes, crosscuts more easily than the pruning saw. In cutting, the pruning saw performs better in congested culms than the bolo. Moreover, the stump and pole ends cut by the pruning saw are blunt compared to the pointed and sharp ends cut by the bolo, which are very prone to cause accidents.

The pruning saw is more expensive than the bolo, which the workers could hardly afford. For greater production and safety, it is recommended that the company provides the workers with the pruning saw. Other cutting saws are also recommended for testing.

The most tiring and production bottleneck in harvesting bamboo plantations is minor transport. For a continuous and steady supply of poles, it is recommended that more roads be built into the plantation. The road should be at the lowest elevation for minor transport to be downhill and easy.

In the natural bamboo stand of Bambusa blumeana Schultes f., there is no harvesting regulation and cutting practices are faulty. Harvesting is wasteful and destructive. Proper harvesting induces growth.

The owner of the natural bamboo stands entail relatively no establishment cost, maintenance cost or harvesting cost. However, for more income, it is recommended that the clump base be cleared and cutting to be at about 30 cm above the ground level for better growth and utilization.

The carabao and sled are very practical for off-the-road transport. The yoke placed over the carabao's neck in which the sled is fastened, carries and pulls the load. The sled is dragged on the ground.

In order not to tire the carabao by giving it a heavier load, it is recommended that the yoke and sled be improved. The yoke could be wider and cushioned and the sled could have a wheel.

PART II

THE PRODUCTION OF FIREWOOD FROM THE BARK OF DIPTEROCARP SPECIES

BACKGROUND

Firewood is a necessity of every day life for household, agricultural and industrial use. It is, however, becoming scarce nowadays for a large number of people in many countries and regions of the world. As a matter of fact, the United Nations Environment Programme identified the severe shortage of firewood as the fourth global environmental problem that is gripping many parts of the third world. The population growth and deterioration of natural forest resources are among the causes for the shortage of fuelwood. Moreover, due to the increasing oil prices and cost of electricity, more households and industries are going back to using wood for fuel.

Wood is still one of the more readily available and less expensive forms of fuel and comes from a renewable source. However, unregulated cutting of trees for fuelwood can also lead to forest denudation and soil erosion which is detrimental to agriculture. The establishment of fuelwood plantations or agroforestry on denuded land can help to maintain and improve the sustainability of, the land use system. Another advantage of fuelwood plantations is that they involve rural people in tree growing, harvesting or collection and distribution of fuelwood for their use or as an additional income.

In the Philippines, a large amount of research and development projects have been carried out on fuelwood. A tree species suitable for fuelwood and charcoal is ipil-ipil (Leucaena leucocephala) and is the most studied one. Ipil-ipil has a heating value of around 4 700 calories/kg, and it is a most promising tree for fuelwood. Being a fast grower, the establishment of large-scale ipil-ipil plantations were initiated purposely for firewood and charcoal production, as well as a source of energy for dendrothermal power plants. However, the recent nationwide psyllid's infestation has slowed down the ipil-ipil fuelwood venture.

However important fuelwood plantations are, due attention should be given to the processing of sawmilling wastes, such as slabs, edgings, trimmings, sawdust and defective wood materials and veneering wastes, such as log cores and trimmings, which are found in huge piles at mill sites and which also are good sources of fuelwood. Such fuelwood is commonly used by those communities near the mills.

As will be described in this report, bark, which is in many cases wasted, can also be a very good source of firewood.

When fuelwood becomes scarce, its price increases and a fuelwood market comes into operation. A situation like this can be financially advantageous for rural communities. In Tagum, Davao del Norte, Philippines, firewood from the bark of dipterocarp logs is a common small-scale forest business.

STATE OF THE ART

The Forest Management Bureau of the Philippines simply defines fuelwood as wood used for fuel or household (cooking) and industrial purposes (boiler fuel) (5). The Philippines Council for Agricultural and Resources Research and Development defines fuelwood as rough wood for use as fuel prepared from waste material such as branchwood, tops, defective or small logs, waste lumber, or from trees cut especially for the purpose and cut into lengths suited to a fire box (1). In its broader meaning, fuelwood is wood or other material obtained from the trunks, branches and other parts of trees and shrubs to be used as fuel for cooking, heating or generating energy through direct combustion, not only in household but also in rural industries. This definition includes bark, roots, leaves of woody plants, or crop residues such as straw, husk and products from the pruning of fruit trees (2).

Bark and waste wood have long been used as fuel for steam and electric energy production in wood industry mills. The bark and waste wood are residue products in wood conversion or milling, thus, it is a cheap fuel (3). By using these residues, the problem of their disposal is also solved because, in the early years, bark was almost entirely underutilized in the wood industry. However, the most traditional and common use of bark is for firewood in millions of rural Philippine homes.

Besides using it as firewood, bark is chipped and pulverized for use in plant growing. It also acts as a protective mulch of the soil and can be used as fertilizer. Bast fibres from the bark of some plants are suitable for cloth-making and pulp manufacture. Bark is also used as house wallings and roofing in some rural areas.

In the early days, bark was used as firewood for household purposes only, however, as firewood is scarce today, bark is now popularly used in bakeries and restaurants.

It has been estimated that about 8% of the total volume of the dipterocarp species is bark (4).

DESCRIPTION OF THE STUDY AREA

The study was conducted in Tagum, Davao del Norte, Philippines. Tagum is located between the forest harvesting areas, and the processing mills in Maco and Davao City. There is one plywood plant in Maco, and nine plywood and blackboard plants in Davao City.

Since the beginning of forest harvesting operations, bark from dipterocarp logs has been used as firewood for home consumption. Late in the early sixties, firewood from the bark, of dipterocarp logs became a small family enterprise. The logs on logging trucks were stripped of bark while the trucks were parked at the forest products checkpoints of the Bureau of Forest Development and at the driver's rest points (see Figure 1).

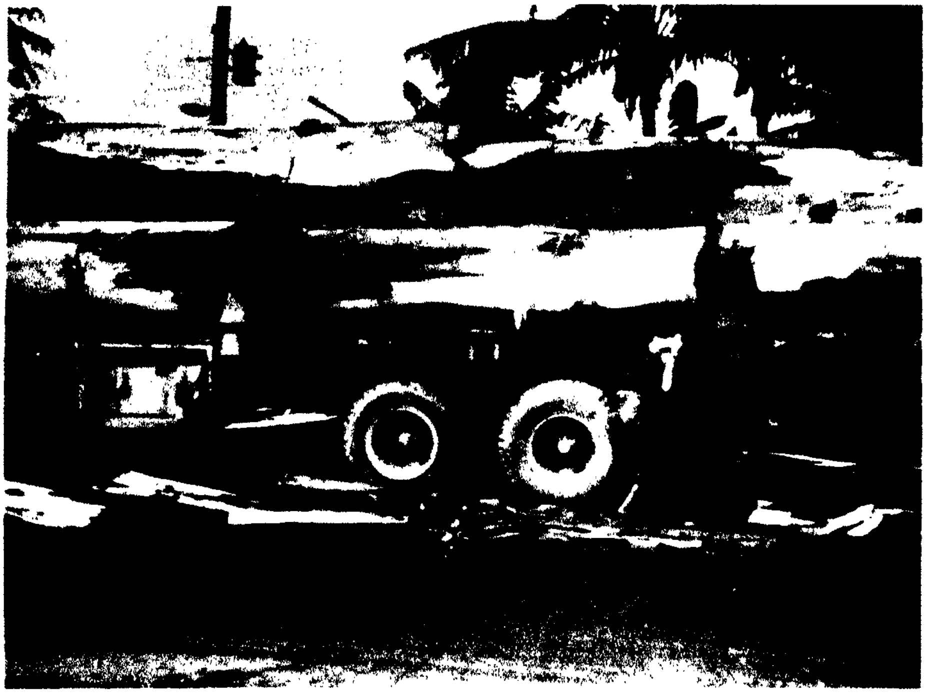

Figure 1

Stripping off the bark of dipterocarp logs

At first, the bark was stripped off free-of-charge, however, due to the growing bark firewood business, and in order to tempt the drivers to stop, they were offered free snacks and later, free meals for their cooperation. At that time, the forest industry in the country was still booming. Later in the mid-seventies when the industries slowed down and the bark firewood industries had gained popularity, there was great competition in stripping off logs on the logging trucks. The driver was then paid P 5.00 per truck. Now, he is paid up to P 50.00 per truck depending on the estimated volume of bark to be stripped. Moreover, the driver's assistant gathers bark strips in the harvesting area and sells it at P 1.00 per strip.

DESCRIPTION OF TOOLS AND ACCESSORIES USED

The tool used for bark stripping is a locally made debarking spud (see Figure 2). The cutting head is made from an old spring of a truck. The width of the blade measures 10 cm and its length is 20 cm. The head is welded to a 1 m steel pipe, which is used as a handle. For chopping and splitting, a bolo (machete) is used which is locally made from a truck spring (see Figure 3). It is especially designed and made for chopping and splitting purposes. The bolo measures 10 cm in width and 30 cm in blade length. The 12 cm handle is an extension of the blade. It is wrapped with rubber for a comfortable grip.

Figure 2

Locally made debarking spuds

Figure 3

A locally made bolo for chopping and slicing the bark

A locally made mallet is also used in the bundling activity for hammering bark splits into the bundle in order to tighten it (see Figure 4). Accessories used are the chopping and splitting block which is made of log ends. A wooden ladder is also used for climbing onto the trucks (see Figure 5). Sharp stones of carburundum are used for sharpening both the debarking spud and the chopping and splitting bolo. A bamboo woven basket is also used as a measuring container for the reject bark pieces (see Figure 6). The bundling material is steel wire from used truck tires (see Figure 7).

WORK ORGANIZATION

Small-scale bark firewood enterprises are a family business. The father or head of the family acts as the manager; he looks for product buyers and estimates the cost of the bark to be paid to the truck driver. Stripping is done by male members of the family. Sometimes, and when urgently needed, especially when various trucks arrive at the same time, women also do stripping on the lower portion of the truck from the ground. When all the family members can not cope with the arriving trucks, stripping is also done by contract workers and stripped bark is divided equally between the contract worker and the entrepreneur.

Figure 4

A mallet for hammering the last splits into the bundle

Figure 5

A wooden ladder is used for climbing onto the trucks when stripping

Chopping, splitting, drying, bundling and storing are usually carried out by all the members of the family. Usually these work phases are done early in the morning and late in the afternoon. They work, as they wish, the whole day to meet their production goals. Bundling is also done by contract workers.

The bark firewood is usually sold by the bundle. Reject bark chops, are sold by the basket load called "bukag" or by the tricycle load. Bark firewood is usually sold to bakeries, restaurants and to the slaughter-house, which needs a large volume of firewood. Bark firewood is also sold to any buyer who would like to buy it, regardless of the quantity he needs. These buyers are either middlemen or end-users. According to the bark firewood entrepreneurs, who were interviewed, they could only supply the town of Tagum because of the great demand. Theoretically, they could sell their products at a higher price in nearby towns, but transportation costs would be too high.

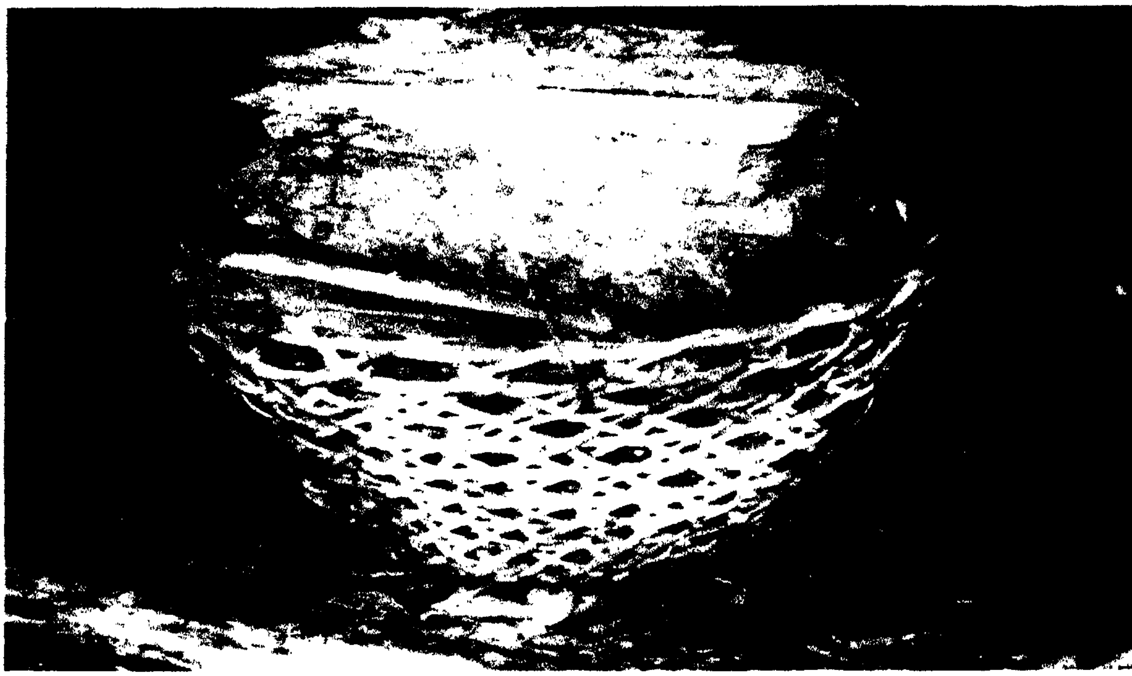

Figure 6

A bamboo woven basket is used as a measuring container when selling the reject bark pieces

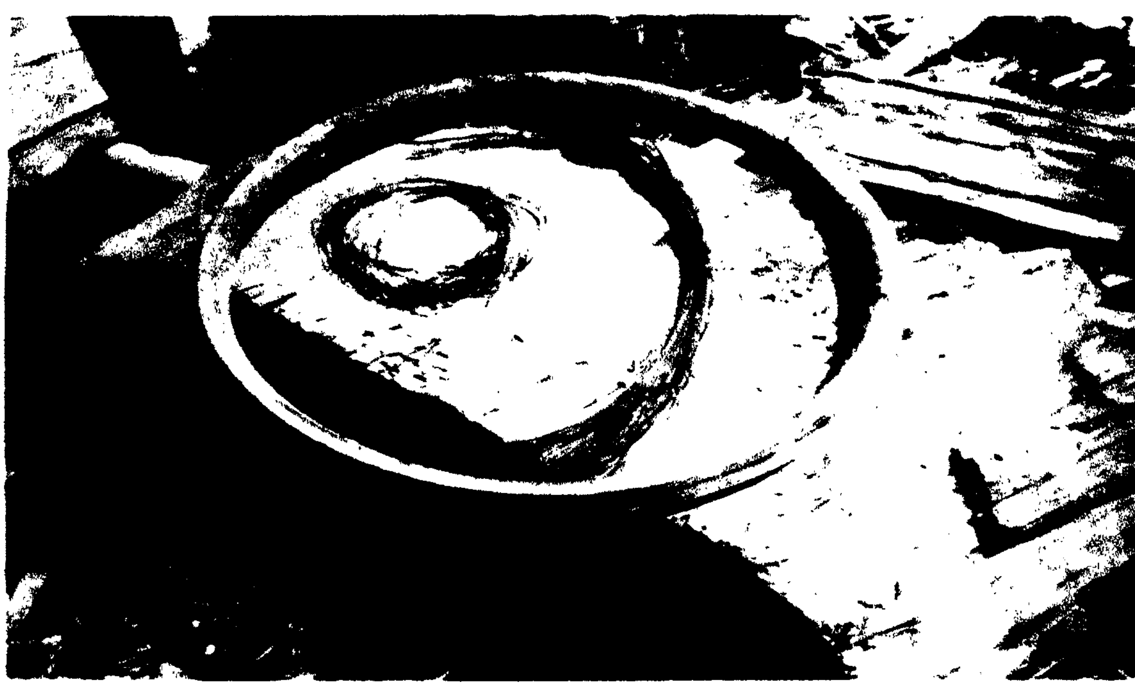

Figure 7

Steel wires from used truck tires for bundling

The selling price of the bark firewood is based on the prevailing price at the locality. Cash and carry and wholesale prices are lower than the delivered and retail price. The price of the bundles will depend on the size.

Labour and other costs of the bark firewood production are difficult to determine because the members of the family undertake this work. If the members of the family cannot cope with the work, it is contracted to some of their neighbours but payment is in the form of bark strips.

The only recorded cost in the bark firewood production is the payment of bark strips to the truck drivers which ranges from P 10.00 to P 50.00 per truck.

WORK PHASES

Seven work phases can be distinguished in the production of bark firewood by a small-scale enterprise.

Stripping

This activity is the debarking of the logs loaded on the trucks. The initiation of the stripping phase will depend on the arrival of the logging trucks, which usually park at the roadside where the enterprise is located. Thus, it can be any time of the day or night, and in any season and weather condition. The worker strips the logs as fast as he can in order not to delay the truck. Two to five workers do this job depending on the number of trucks available. Sometimes, the trucks arrive at the same time so the workers are divided among the trucks. There is only one buyer of bark for each truck and every truck has a regular buyer. Family members do the stripping but if they cannot cope, contract workers are also employed. The contract worker in log stripping receives half the amount of the bark he strips as payment. Sometimes he sells the stripped bark to the entrepreneurs at P 1.00 per bark strip.

Bark of Bagtikan (Parashorea plicata), Almon (Shorea almon) and Mayapis (Shorea squamata) were claimed by the workers as the best species for bark firewood because of its thickness and easiness in stripping. White lauan (Pentacme contorta), Red lauan (Shorea negronesis), and tangile (Shorea polysperma) were also a common source of bark firewood. The loads of the trucks fluctuate from 12 to 14 m^3. About 75 to 80% of the log surface is stripped off. Portions of the logs that are held with log binders and which are in contact with other logs are not stripped. However, as long as the worker can reach the logs and their tool can penetrate, the logs are stripped off.

Having stripped off the bark, the bark strips are dropped from the truck. Once the stripping is finished and the truck has left, the bark strips are piled in the yard of the enterprise (home of the owner, see Figure 8).

Figure 8

Bark strips pile

Chopping

Chopping is the transversal cutting of bark strips into sections called bark chops (see Figure 9). The irregular end of the bark strips are trimmed first. For regular chopping, the length of the bolo is used as a measuring guide. Good quality bark strips, larger in width and thickness, are chopped into regular length. However, poor quality ones, the narrow and thin bark strips, were chopped shorter and graded as rejected bark. When demand for reject bark increases, even good quality bark strips are made into reject bark, in order to increase the sales.

Splitting

Splitting is the longitudinal cutting of bark chops into sections called bark splits (see Figure 10). The width of the bark splits depends on the end use. For household cooking the average width of the split is 3 cm, while that of the wide split for bakeries and restaurants is 7 cm. Trimming of the irregular sides of the bark chops is done before splitting. Reject bark chops are not split.

Drying

Chopping and splitting is done when the bark strip is still green. Bark splits and reject chops are dried in the sun. The bark splits are piled in a crisscross pattern to allow air to circulate in between the splits (see Figure 11). Reject bark chops are dried by laying them on

Figure 9

Chopping of a bark strip

Figure 10

Splitting of bark chops

Figure 11

Drying of bark splits

Figure 12

Drying of reject bark chops

the ground with the inner bark side up, which has a greater moisture content than the outer bark side (see Figure 12). Bark splits usually take three days to dry in the sun.

During the rainy season, the splits are piled on an elevated platform with roofing under which a fire is lit with the trimmings of the chops.

Bundling

After drying, the bark splits are bundled. To standardize the diameter or size of the bundle and easiness of bundling the wire from used tires is coiled and tied firmly into a circle or loop of the required diameter. Bark splits are inserted into the wire loop and a tight compact bundle is made by forcing the last bark splits into remaining spaces with a mallet (see Figures 13 and 14). Only one wire loop is used at the middle of the bundle. The reject bark chops are not bundled.

Figure 13

Bundles are made by inserting bark splits into the standard size wire loop

Figure 14

The last splits are driven into the bundle with a mallet

The size of the bundles varies according to the preference of the producer. The bundle of thin splits has three diameter sizes: 10 cm, 20 cm and 30 cm, with an average number of bark splits of 12, 28 and 42, respectively. The wide splits bundle diameter is 15 cm and the average number of bark splits per bundle is 9. The length of the bundle has a standard size of 42 cm, equivalent to the length of the bolo.

Bark firewood bundles and reject bark chops are piled on the road-side ready for sale. The piles are covered with plastic sheets or with galvanized iron sheets to protect them from rain (see Figure 15).

Storing

In preparation for the rainy season, bundled bark firewood and the reject bark chops are also stored in a shed. During the rainy season when dry firewood is scarce, the stored bark firewood is mostly sold to the regular buyers or customers.

Figure 15

Bundles of bark firewood

Delivery

Delivery of bark firewood to the buyers is not common. This is only done in the case of regular buyers, especially when they buy wholesale. Delivery is usually done by tricycle to bakeries, restaurants and to bark firewood retail stores (see Figure 16).

Other related activities

Tool maintenance

The debarking spud, chopping and splitting bolo are sharpened regularly with a carburundum sharpening stone (see Figure 17).

Preparation of bundling wire

Used truck tires are set on fire in order to remove the rubber coating of the wire. After extracting the wire, it is cut to the desired length, depending on the size of the loop to be made.

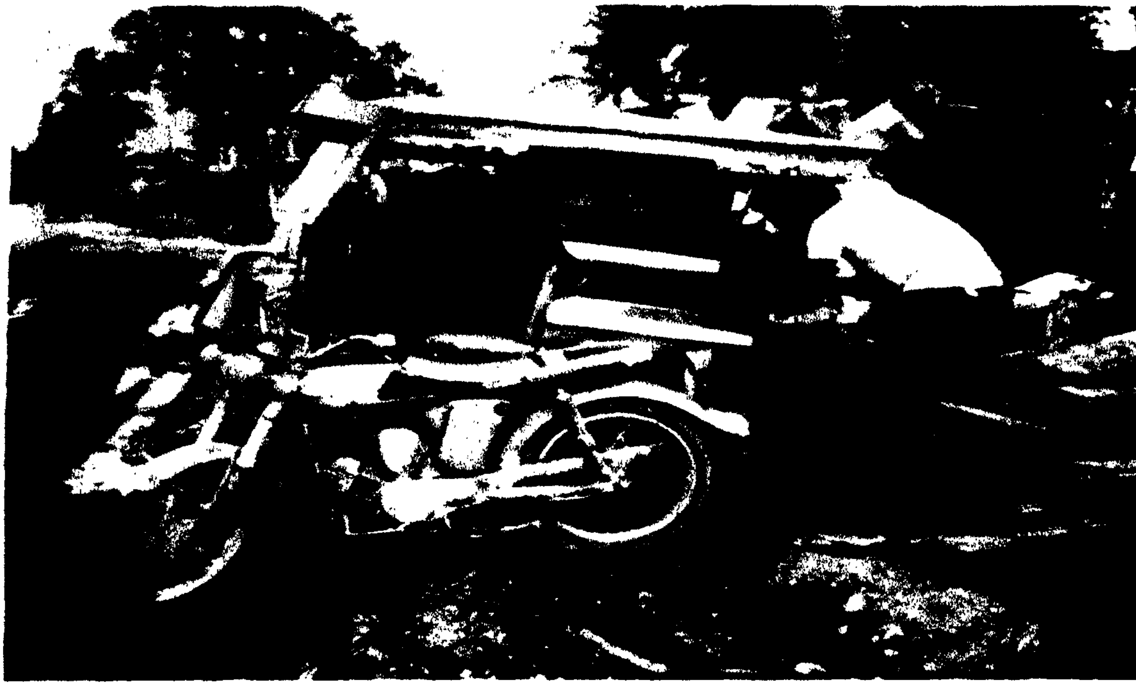

Figure 16

A tricycle is used for the delivery of bark firewood

Figure 17

Tool maintenance

TIME AND WORK STUDY

The collection of field data was done through observations of the working phases, personal interviews and measuring output. There were three bark firewood enterprises that were observed during September 1987. Some data was also gathered from the personal records of one entrepreneur.

Time studies were carried out on some of the work phases using the continuous timing method. The time was measured with a stopwatch, graduated in 60 seconds. Output was either measured in cubic metres or recorded as number of splits and bundles.

Work phases for which time studies were carried out are: stripping, chopping, splitting and bundling.

RESULTS

Stripping

Stripping time was recorded for 4 trucks. Bark volume is measured by piling the bark strips and measuring the pile dimensions. The average width and length taken from 50 bark strip samples were 30 and 212 cm respectively. The length of bark strips ranges from 115 to 400 cm.

The average stripping time per truck is 63 man-minutes with an average stacked bark strip volume of 0.7 m^3 per truck. The calculated production is 0.67 m^3 per manhour for stripping.

Chopping

The recorded chopping time was 48 minutes for producing 369 bark chops from 52 bark strips. The total stacked volume of the bark strips was 0.52 m^3. Dividing 60 minutes by the total chopping time and multiplying the result by the output gives a chopping production of 0.65 m^3/hr.

Splitting

The recorded splitting time was 52 minutes producing 570 thin splits from 116 bark chops. One bundle of 12 thin splits has a volume of 0.003 m^3. The splitting production is 0.16 m^3 per manhour.

Bundling

Bundling thin splits in small bundles has an output of 47 bundles per manhour. The calculated volume per bundle is 0.003 m^3, thus, the production is 0.14 m^3 per manhour.

Bundling thin splits in medium bundles has an output of 13 bundles per manhour. The calculated volume per bundle is 0.013 m^3, thus, the production is 0.17 m^3 per manhour.

Bundling wide splits has an output of 65 bundles per manhour. The calculated volume per bundle is 0.007 m^3, thus, the production is 0.5 m^3 per manhour.

The diameter of the thin splits small bundle, thin splits medium bundle and wide splits bundle are 10 cm, 28 cm and 48 cm respectively.

Bark firewood production

It takes 16.5 hours for one cubic metre stacked volume of bark strip to be stripped, chopped, split (thin split) and bundled (small thin splits bundle). Bark firewood production, which excludes drying, storing and delivery time, is 0.06 m^3/hr. On an effective 5-hour working day, the bark firewood production (small thin splits bundle) is 0.3 m^3 per day.

CONCLUSIONS AND RECOMMENDATIONS

Bark from dipterocarp logs is a good potential source of raw material for firewood and is a profitable small-scale enterprise in which the rural people are benefitted. There was no record available on its profitability, but according to the entrepreneurs interviewed, their business could support their daily expenses. One of the entrepreneurs claimed that the cost of his children's education was covered by the business.

It is necessary to have investment and working capital to begin with the bark firewood business. It is recommended that the government and other private institutions avail loans to these rural people interested in the business. Moreover, bark firewood entrepreneurs have to organize themselves and form a cooperative. In this way, they can pool their products and avail themselves of the facilities that can be provided by the cooperative with the aid of the government. The cooperative can also increase the transport capability of the products to further away market centres where the prices are higher.

Indirectly, the bark firewood business saves or controls the cutting of small commercial trees in the forests. The rural people preferred to gather the bark rather than cut down trees as it was an easier task.

In addition, it helps the wood industry in debarking their logs before processing and in the problem of bark waste disposal.

Bark firewood is very popular to the nearby logging communities. However, it is not widely used in far away communities. Bark firewood should be promoted in other far flung communities in order to keep them aware that bark is a good source of firewood. In this case, the use of expensive gas and electricity is minimized.

The workers are well adapted to the tools used in stripping, chopping and slicing. However, the tools are too heavy for a child to use. Research on alternative appropriate tools is recommended.

PART III

HARVESTING OPERATIONS IN A MANGROVE FOREST

BACKGROUND

Mangrove forests are common in the humid tropics and distributed worldwide.

The funtion and use of the mangrove ecosystem are varied and numerous. In the field of forestry, most of the interest is the timber and wood resource which is the major component of the Mangrove Ecosystem.

The industrial or economic use of mangrove forests has a long history. Mangrove wood is excellent for charcoal making and an important source of fuelwood. Most of the mangrove wood is highly durable and is used as railroad ties, foundation piles and fishing stakes. It also offers a good material for scaffold poles and house construction in rural areas. The mangrove wood is processed into wood chips for pulp. Tannin extracted from the bark of most of the mangrove species is primarily used in the leather manufacturing industry. There are also many traditional or folk uses of mangroves, such as medicine.

The mangrove ecosystem serves as a coastline stabilizer, a retainer and builder of land, a buffer against waves and flood, a protection of streams, river banks and as a coastal pollutant sink or trap (3,11). It also serves as a nursery, spawning and feeding ground for fish and shellfish and serves as a sanctuary for a variety of wildlife.

Most of the studies undertaken in mangrove forests have been on the silvicultural aspects and very little has been done concerning harvesting operations.

STATE OF THE ART

Mangrove forests thrive on swampy areas and no heavy machinery has been used for harvesting. Thus, harvesting operations are labour-intensive.

In Indonesia, felling is carried out with an axe and bucking is done by chainsaw. Debarking is performed with a local machete called barang. When a tree is newly felled, debarking is very easy. Land transport to the riverside or directly to the depot at the seaside is carried out by a manually pushed and/or pulled sledge called ongkaka and by small steel wheeled wagons which are pushed and pulled along narrow gauge railway tracks that are mounted on roundwood cross members laid on two parallel pole stringers. Water transport is carried out with a barge or a ship. (5)

In Thailand, chainsaws are used for felling the trees, trimming branches and cutting the stem into billets. After the trees have been felled and cut into 2 m billets, workers carry the billets out from the forest and load them onto boats with outboard engines (6).

In Venezuela, stems and poles are hauled to the staking site by the river bank by using a high-lead system mounted on a floating barge with two barge settings in each 50 m wide clearcut strip. The poles and billets are transferred onto barges and transported to the jetty (landing). Occasionally, small boats are used to transport the timber to the barges, especially when stacking sites are on the banks of shallow creeks (8).

In the Philippines, the "seed tree-and-plant method" is the silvicultural method used which means that at least 20 trees with a diameter of 10 cm and above must be left undamaged after harvesting, and regeneration should be supplemented by planting (5).

In Viet Nam, charcoal production forests have a diameter limit of 4 cm on a twenty-year rotation with a minimum of 30 to 40 seed trees per ha (6).

In Bangladesh's sunderbans, minimum diameter limits are prescribed for all commercial species, varying between 19 cm to 56 cm in a selective cutting system (6).

In Indonesia, harvesting is by "stripwise-selective-felling" which means that trees with a 7 cm diameter and above are felled in 50 m wide strips perpendicular to the coastline. These strips must be interspread with 20 m undisturbed strips. The rotation is 20 years. Replanting must be carried out where saplings and seedlings are scarce or lacking (5).

A clear felling system is practised in the Klang mangrove forest in central Peninsular Malaysia. The rotation period is 25 years. After two years of clear fèlling, planting is done on poorly stocked areas (1,13). Mangrove forests in South Johor have a rotation period of 20 years (11).

In Sabah, selective felling in the form of a minimum girth system is the silvicultural method used (7). For charcoal production, the girth limit is 20 cm while 10 cm girth limit is for firewood and fishing stakes. However, if the forest are evenly sized, cutting results in clear felling and 40 seed trees are left per hectare. A buffer of trees along waterways and coasts is left undisturbed.

A woodchip company in Sarawak, carries out systematic harvesting of the mangrove forest following a working plan. The area under this company is managed on a sustained yield basis with a 25 year rotation. The minimum felling limit is 23 cm girth at breast height (2).

In Thailand, a shelterwood system with a minimum girth limit and a rotation of 15 years was found to be unsuccessful. This technique decreases the yield and stock of the forest from one cutting cycle to another. Clear felling in alternate strips was tried and applied in 1967 and the system shows satisfactory results (12).

DESCRIPTION OF THE STUDY AREA

The study was conducted in the Matang Mangrove Forest Reserve, located on the north western coast of Peninsular Malaysia along the straits of Malacca.

Matang mangrove forest

The best managed mangrove forest area in Malaysia and probably worldwide is the Matang Mangrove Forest Reserve (see Figure 1). The total are, at present is estimated to be 40 711 ha, of which 34 769 ha are considered to be productive forest and 5 942 ha unproductive.

The Matang Mangrove Forest is divided into three ranges namely: Port Weld, Kuala Trang and Sungai Kerang. Each range is further divided into compartments, totalling 108 compartments in the whole area.

Figure 1

A 30-year old mangrove stand ready for the final harvest

The forests are divided by numerous rivers and many waterways. Since the waters in the vicinity of the forests are a rich fishing ground, five fishing villages exist within the Matang Mangrove Forest.

Management working plan

The Perak State Forest Department has the jurisdiction and responsibility of managing the forest, controlling the harvesting, and protecting and rehabilitating the area if the need arises after the final harvest. The primary objective of the mangrove forest management is sustained yield giving consideration to its natural importance as a valuable ecosystem.

Historically, Matang Mangrove Forest has been managed since it became a reserve in 1902. In order to meet and carry out the management objectives, a working plan is prepared which is revised every ten years.

The productive forest has been divided into three blocks, each consisting of about 11 590 ha of productive forest. Basically, age is the main criteria for such a division. Block 1 has forests in the age class 21-30 years; block 2, in the age class 11-20 years and block 3, in the age class 1-10 years. Block 1 has been sub-divided into ten 1-year sub-blocks corresponding to the ten allocations.

The management plan assigns charcoal and firewood allotments. The study was undertaken in the charcoal allotments both for thinning and for final harvest operations.

Forest yield

The expected average yield of the forest at rotation age in the charcoal allotments is 177 t/ha which is equivalent to 166 m^3/ha. In the firewood allotments it is 146 t/ha at rotation age. In the thinning operations of the charcoal allotments, the first thinning average yield is 1 400 trees and the second thinning average yield is 1 800 trees which are converted to poles and piles.

For charcoal production each brick kiln requires about 2.8 ha of forest area each year for full operation. The annual average allocation of forest area for charcoal production is 896 ha. This area can annually support an average of 320 charcoal kilns. The kiln constructed in the region resembles an igloo. They have a capacity of around 40 t of mangrove billets. The yield is around 11 t per burn. The charcoal processing takes about 28 days.

The common commercial species are: Rhizophora mucronata, R. apiculata, Bruguiera gymnorhiza, B. cylindrica, B. parviflora, and Ceriops tagal.

Silvicultural system

The silvicultural system is clear felling with the retention of seven mother trees per hectare and enrichment planting.

The prescribed rotation cycle is 30 years and thinnings are carried out at the age of 15 and 20 years. The following operation sequences took place during the 30-year rotation of the forest:

Year	Operation
- 1	Enumeration with a 4% intensity of all trees of 8 cm diameter and above, to obtain information on growing stock, species available and eventually to assess the premium to be paid for the area.
30/0	Final harvest of all trees of 8 cm diameter and above. Seven good trees are marked for retention as mother trees for every hectare of the annual cutting area. These trees are concentrated at the boundaries of the allotments. Previously, these trees were evenly distributed in the allotments but the wind caused a lot of damage. A 3 m buffer of trees is left along rivers and sea to prevent or reduce erosion as well as for seed propagation (see Figure 2). Before leaving the area, the charcoal contractors have to girdle all non-commercial trees.
1	The area is inspected and the stocking of the regeneration is roughly estimated. Natural regeneration, which is below 90% of the desired stocking, needs artificial regeneration. Invading ferns are eradicated by chemical spraying.
2	Planting is carried out on areas which are not fully regenerated, usually from July to December. The species planted are _Rhizophora apiculata_ and _R. mucronata_ at a spacing of 1.2 x 1.2 m and 1.8 x 1.8 m respectively. A seed orchard has been set aside to supply seeds and a nursery has also been established.
3	The area is again inspected and the survival rate is determined. If the survival rate is less than 75%, replanting is carried out during the planting season. Weeding is carried out when necessary.
15-19	The trees are ready for the pole market. One good quality tree is selected to be retained and all the trees within the 1.2 m radius are to be cut.
20-24	Thinning II is carried out five years after thinning I, using a 1.8 m radius. The procedure is the same as in thinning I but this time larger poles are extracted.
30	Final harvest.

DESCRIPTION OF EQUIPMENT AND TOOLS

Felling, bucking and delimbing

An Echo 30-40 cc chainsaw with a 40 cm bar was used in the final harvest for felling, bucking and delimbing operations. An iron mallet and wedge were also used in the felling operation.

An axe was used in the thinning operation for felling, bucking and delimbing (see Figure 3).

Figure 2

A 3 m wide uncut buffer zone is left along the river banks to prevent the erosion and to facilitate the regeneration

Figure 3

An axe is used for pole preparation in thinning

Debarking

Only charcoal billets in the final harvest were debarked in the harvesting area, while the billet is still green. A wooden mallet made by the workers themselves is used (see Figure 4). The mallet is carved from a mangrove stump with a prop root. The size of the mallet varies, however, the average length is around 40 cm and the mallet head is 20 cm wide.

Debarking is an easy task when the wood is green. At the yard of the charcoal kiln, debarking relatively dry billets is done with a debarking spud.

Minor transport

In the final harvest, the minor transport of the charcoal billets is done with locally made wheelbarrows (see Figure 5). The wooden wheel of the wheelbarrow is tapered towards the wheel edge on which an iron band is fitted around the wheel to strengthen the contact surface. The wheel is made from a piece of wood but sometimes two pieces of wood are joined together. The wheel is fixed to the square section of the axle. The end axles are round and pass through ball bearings fastened at the front of the main frame. The wheel diameter is 40 cm. The length of the wheelbarrow which resembles an A-frame is 230 cm, with a 15 and 70 cm clearance on the front and back, respectively. The legs of the wheelbarrow are 40 cm in height.

Figure 4

A wooden mallet is used for debarking

Figure 5

A wheelbarrow is used for the minor transport of billets

The wheelbarrow is driven on a plank walk, which is laid out before felling the trees (see Figure 6). The chainsaw operator cuts the stumps close to the ground on the plank walk path. The width of the plank walk path is 2 to 2.5 m. Small diameter billets of about 1 m in length are laid on the path parallel to each other with a separation of 0.5 to 1 m. The billets serve as the cross ties of the plank walk. The planks of 3 cm in thickness, 18 cm in width, and 5 m in length are laid in a line on the cross ties. Only both ends of the plank are nailed to the cross ties. Sometimes, switches are included in the main plank (see Figure 7). The construction of the plank walk progresses as the harvesting operations progress inland.

During the thinning operations minor transport of poles was carried out manually. There were no plank walks but one metre long billets had been laid across the minor transport path at a one step interval.

WORK ORGANIZATION

The work organization is described for the final harvest and thinning operations. The operations are carried out by the contractors and supervised by the Perak Forestry Department.

Figure 6

A plank walk was constructed for the wheelbarrow

Figure 7

A plank walk switch with a wheelbarrow guide nailed to the main plank walk

Final harvest

The charcoal contractor employs the workers on a piece rate basis. The contractor provides the wooden planks, nails and a temporary shelter within the forest. A single contractor employs up to 11 crews of workers. Each crew is normally composed of three workers. One is the chainsaw operator, the other is the chainsaw assistant and the third carries out the minor transport of billets.

The workers start working at 7:30 hours. From 11:30 hours they have a lunch break and a long rest up to 15:00 hours after which they work until 19:30 hours.

The timing of the work depends on the high and low tide periods. The workers work up to ten days continuously during the high tide period and take a 5 day break during the low tide period. Thus, the total working days per month is 20. The workers live in the harvesting area during work days and go home for the five day break period.

Each crew is assigned a 20 to 30 m by 200 m lot in the sub-allotments. Thus, in each sub-allotment a number of crews work at the same time. The size of the lot is appropriate for a plank walk in the middle of the allotment.

The chainsaw, wheelbarrow, axe and other tools used in harvesting are owned by the crew who equally share the cost. The maintenance cost of the equipment is deducted from the crews gross earnings and the balance is equally shared among the members.

The charcoal contractor pays the harvesting team on a piece rate basis of M$ 177 per 150 pikuls, which is a "tongkang" boat load and equivalent to 8.5 m^3.

A crew produces one boat load per day. Each worker earns about M$ 700 net per month, having subtracted the total equipment and tool cost at the rate of M$ 11 per day.

Thinning

In the thinning operations, 6 to 8 workers are assigned to 1 sub-allotment and each worker is assigned to a 20 to 30 m by 200 m lot. The worker does the felling, bucking, delimbing and minor transport of poles to the water edge.

The worker receives M$ 1 per pole up to a minor transport distance of 40 m. When the distance is from 40 m to 100 m, he is paid M$ 1.10 per pole and beyond 100 m, M$ 1.20 per pole.

Each worker in the thinning operation earns between M$ 500 and M$ 700 per month.

HARVESTING TECHNIQUES

The harvesting techniques are different in final harvest and in thinning.

Final harvest

In the final harvest, one can distinguish the following work phases: felling, bucking, delimbing, debarking and minor transport.

Felling

The chainsaw operator clears around the tree and cuts some of the prop roots which hinder the operator to come closer to the tree for felling. The felling height is just above the highest prop root (see Figure 8). The felling direction is towards the plank walk or if the tree is beside the plank walk, it is felled parallel to it. A wedge is used to force the fall of the tree. A batch of around ten trees are felled so that the billets can be easily debarked. This also reduces congestion of the fallen trees and facilitates bucking, delimbing and debarking. After one batch of trees has been bucked, delimbed, debarked and piled to the sides of the plank walk, another batch of trees is felled. Usually, the number of trees to be felled is just enough for a day's work.

Figure 8

Final harvest felling operation

Bucking and delimbing

Bucking length is 1.6 m. The assistant marks the bucking length using a stick for measuring and an axe for marking. Branches that hinder marking are eventually cut by the assistant with the axe. The chainsaw operator normally follows the assistant and bucks the tree (see Figure 9). More often than not, a couple of trees are delimbed and bucked simultaneously. The minimum diameter for charcoal billets is 7.5 cm, however, tops and branches smaller than 7.5 cm are also gathered for firing the charcoal kiln.

Debarking

After bucking, the billets are debarked at the stumpsite, by hammering the billet with the mallet and piled beside the plank walk (see Figure 10).

Figure 9

Bucking and delimbing

Figure 10

Debarking the billet with a mallet

Billet minor transport

Billets are then transported to the water edge using a wheelbarrow driven on the plank walk. While being loaded, the wheelbarrow legs rest on two planks. Sometimes, they rest on the cross poles but the planks are more stable. The billets are loaded cross-wise on the wheelbarrow to ease unloading.

Braided rattan shoulder straps are used to help lift and balance the wheelbarrow. Both ends of the strap have a loop in which the wheelbarrow handles or levers are placed. The loaded wheelbarrow is then pushed to the water edge.

In the unloading area, a 1.5 metre wide plank platform has been constructed to facilitate parking the wheelbarrow (see Figure 11). The billets are to be piled perpendicular to the water edge across two poles laid on the ground.

Figure 11

Wheelbarrow parking platform at the landing

The wheelbarrow is parked alongside the water edge perpendicular to the billets pile. Thus, unloading is carried out by just pulling the billets onto the pile. The empty wheelbarrow is then pulled back to the stump site.

Thinning

Thinning is an intermediate operation to increase the yield of wood for charcoal in the final harvest. It is a profitable and commercial operation, producing poles for local consumption.

In thinning operations, there are two work phases, namely: pole preparation and pole minor haul.

Pole preparation

The pole preparation, including felling, bucking and debranching of trees, is done by axe (see Figure 12). To control over-cutting, chain-saws are not allowed. The pole lengths produced are 5 and 6 m. The length of the axe is used to measure the pole length (see Figure 13).

Pole minor transport

The poles are carried manually on the shoulder to the water-edge (see Figure 14). The poles are piled perpendicular to the water edge over the two poles laid on the ground.

Figure 12

In thinnings, mangroves are felled with an axe

Figure 13

The axe is also used for measuring the pole

Figure 14

In thinnings, the poles are carried manually to the landing

TIME AND WORK STUDY

Initial observations were carried out to become familiarized with the work phases and elements. Data gathering took place during March 1988.

Time studies were carried out on the work phases using the continuous timing method with a digital stopwatch. Distance was measured with a 25 m tape. The output was calculated in cubic metres in the final harvest and recorded as number of poles in the thinning operations. Delays in each work phase were noted and recorded.

The calculation of the time and production of the work phase and elements, which are not affected by the distance, is by averaging. The total sum of all time observations of the phases or element is divided by the total number of observations.

The work phases and elements not affected by the distance are billet preparation (felling, bucking and delimbing, and debarking), pole preparation (felling, bucking and delimbing, and piling), loading and unloading.

On the other hand, the calculations of the time and production of the work elements affected by the distance is by calculating the time and production per unit distance. This is done by dividing the total time of all the observations for the elements by the total distance of all observations. The elements affected by the distance are unloaded trip and loaded trip.

Final harvest

Two work phases are identified, namely: billet preparation and billet minor transport.

Billet preparation

Billet preparation is divided into three work elements as follows:

Felling

Felling starts when the chainsaw operator and the assistant walk to the tree to be felled, clear the surroundings and fell the tree. It ends when the tree finally falls to the ground.

Bucking and delimbing

Bucking and delimbing starts when the chainsaw operator and the assistant walk to the tree. It ends when the tree is fully bucked. More often than not, bucking and delimbing are simultaneously done on a couple of trees. In this case, bucking and delimbing time is divided by the number of trees being simultaneously bucked and delimbed.

Debarking

Debarking starts when the worker takes a newly bucked billet and ends when the billet is fully debarked and piled by the plank walk.

Billet minor transport

Billet minor transport is divided into four elements as follows:

Unloaded trip

The unloaded trip starts when the worker leaves the unloading point with the wheelbarrow and ends when the wheelbarrow reaches the loading point (see Figure 15).

Loading

Loading starts when the worker picks up the first billet and ends when the wheelbarrow is fully loaded (see Figure 16).

Figure 15

Unloaded trip of the wheelbarrow

Figure 16

Loading the wheelbarrow

Loaded trip

The loaded trip starts when the rattan strap is fastened to the wheelbarrow handle and ends when the loaded wheelbarrow is properly parked at the unloading point at the water edge (see Figure 17).

Unloading

Unloading starts when the worker begins to pull or carry the billet to the pile and ends when the wheelbarrow is fully unloaded (see Figure 18).

Thinning

Two work phases were identified in the thinning operation, namely: pole preparation and pole minor transport.

Pole preparation

The pole preparation phase consisted of felling, bucking and delimbing and piling.

Figure 17

Loaded trip of the wheelbarrow

Figure 18

Unloading the wheelbarrow onto the wateredge pile

Pole minor transport

The pole minor transport is divided into two elements as follows:

Unloaded trip

Unloaded trip starts when the worker leaves the water edge and ends when the worker arrives at the stump site.

Loaded trip

Loaded trip starts when the worker begins to pick a pole at the stump site and it ends when the pole is dropped onto the wateredge pile.

RESULTS

Time standards: Final harvest

Time standards were calculated for billet preparation and billet minor transport.

Billet preparation

Time standards were calculated for felling, bucking and delimbing and debarking.

Felling

Four chainsaw operators and assistants were observed in the felling operations. There were 65 samples of felling time collected. The average felling time involving 2 workers (the chainsaw operator and the assistant) is one minute per tree. Since there were two workers involved, the total average felling time was 2 man-minutes per tree.

Bucking and delimbing

Three chainsaw operators and assistants were observed in the bucking operation. The average bucking time was 2.5 minutes per tree. There were two workers involved, thus, the total average bucking time was 5 man-minutes per tree.

Debarking

There were five workers observed in the debarking operation and 110 debarking time samples were gathered. The average debarking time was 2.2 man-minutes per billet.

Billet minor transport

Time standards were calculated for unloaded trip, loading, loaded trip and unloading. There were 47 round trips and a total one-way distance of 4 745 m studied.

Unloaded trip

The total unloaded trip time was 71. The unloaded trip time per metre is:

$$ULT_t = \frac{71}{4745} = 0.015 \text{ minutes/m}$$

The equation for the unloaded trip time would be:

$$ULT_t = 0.015X$$

where:

ULT_t = unloaded trip time, in minutes

X = distance, in metres.

Loading

The total loading time was 110 minutes, thus, the time standard is as follows:

$$L_t = \frac{110}{47} = 2.3 \text{ minutes/load}$$

Loaded trip time

The total loaded trip time was 87 minutes. The loaded trip time per metre is:

$$LT_t = \frac{87}{4745} = 0.018 \text{ minutes/m}$$

The equation for the loaded trip time would be:

$$LT_t = 0.018X$$

where:

LT_t = loaded trip time, in minutes

X = distance, in metres.

Unloading

The total unloading time was 73 minutes, thus, the time standard is as follows:

$$UL_t = \frac{73}{47} = 1.6 \text{ minutes/load}$$

Billet minor transport round trip time

The billet minor transport round trip time is the sum of the elements. The equation would be:

$$BMT_t = 2.3 + 1.6 + 0.015X + 0.018X$$

$$= 3.9 + 0.033X$$

where:

BMT_t = billet minor transport round trip time, in minutes

X = distance, in metres

Time standards: Thinning

Time standards were calculated for pole preparation and pole minor transport.

Pole preparation

A total of 111 poles were produced from 80 trees in 291 minutes. The time standard in the pole preparation is 2.6 minutes per pole.

Pole minor transport

There were 108 round trips and a total one-way distance of 6 328 m studied. The total round trip time was 329 minutes. Time standard for the round trip is 0.05 minutes per metre.

Production standards: Final harvest

Production standards were calculated for billet preparation and billet minor transport.

Billet preparation

Production standards were calculated for felling, bucking and delimbing and debarking.

Felling

The computed average volume per tree felled is 0.3 m³. Felling production standard in cubic metres per manhour is calculated by dividing 60 minutes by the time standard and multiplying it by the volume per tree, thus:

$$F_p = \frac{60}{2} \times 0.3 = 9.0 \text{ m}^3\text{/manhour}$$

Bucking and delimbing

Bucking and delimbing production standard was computed as in felling, thus:

$$B_p = \frac{60}{5} \times 0.3 = 3.6 \text{ m}^3\text{/manhour}$$

Debarking

The computed average billet volume is 0.03 m³. Debarking production standard in cubic metre per manhour is calculated by dividing 60 minutes by the time standard and multiplying it by the average billet volume, thus:

$$D_p = \frac{60}{2.2} \times 0.03 = 0.8 \text{ m}^3\text{/manhour}$$

Billet minor transport

The average number of billet per wheelbarrow load is 10, thus the average wheelbarrow load is 0.3 m³.

The minor transport production standard was calculated by dividing 60 minutes by the minor transport round trip time, which results in the number of round trips per hour. Multiplying it by the average load gives the billet minor transport production standards, thus the equation is:

$$BMT_p = \frac{60}{3.9 + 0.033X} \times 0.3$$

where:

BMT_p = billet minor transport production standards, in m³/hr

X = distance, in metres.

Table 1 shows the calculated minor transport production standards by the distance.

Table 1

Billet minor transport production standard

Distance (m)	Trips per hour	Production (m^3/hr)
50	10.8	3.2
100	8.3	2.5
150	6.8	2.0
200	5.7	1.7

Final harvest operation

The final harvest operation production is the sum of the work phases and is calculated as follows:

The time consumption of billet preparation is the sum of the time consumption of the work elements, thus:

$$\frac{1}{BP_p} = \frac{1}{F_p} + \frac{1}{B_p} + \frac{1}{D_p} = \frac{1}{9.0} + \frac{1}{3.6} + \frac{1}{0.8}$$

$$= 0.11 + 0.28 + 1.25 = 1.6 \text{ manhours/m}^3$$

The time consumption in billet minor transport for a distance of 100 m is:

$$\frac{1}{BMT_p} = \frac{1}{2.5} = 0.4 \text{ manhours/m}^3$$

The total time consumption and the production rate (FH_p) in the final harvest are thus:

$$\frac{1}{FH_p} = 1.6 + 0.4 = 2 \text{ manhours/m}^3$$

$$FH_p = 0.5 \text{ m}^3\text{/manhour}$$

The production standard for the team is 1.5 m^3 per team-hr.

Dividing 8.5 m^3, which is the team's minimum daily production target, by the production rate and by the number of team members, gives the team's minimum effective working hours per day (TWH):

$$TWH = \frac{8.5}{0.5 \times 3}$$

$$= 5.7 \text{ hr}$$

Production standards: Thinning

Production standards were calculated for the pole preparation and pole minor transport.

Pole preparation

Pole preparation production standard is 23 poles/manhour.

Pole minor transport

Pole preparation production standard can be derived from the formula:

$$PMT_p = \frac{60}{0.05X}$$

where:

PMT_p = pole minor transport production standard, in poles/manhour

X = distance, in metres

Table 2 shows the pole minor transport production standards by the distance.

Table 2

Pole minor transport production standards

Distance (m)	Trips per hour	Production (poles/manhour)
50	24	24
100	12	12
150	8	8
200	6	6

Thinning operation

The production of the whole thinning operation at 100 m distance is 7.9 poles per manhour.

CONCLUSIONS AND RECOMMENDATIONS

Mangrove forests offer a variety of direct and indirect products and free services. These products form the basis for mangrove- dependent economic activities vital to coastal rural people. The multiple and sustained free services of mangrove forest which are often ignored, provide basic services typically needed by a coastal rural and even urban communities.

Commercial and traditional products taken from the mangrove range from the wood to medicines and food. Mangrove is used as an important source of charcoal to meet the increasing need for fuel. Wood from mangrove is a good construction material for poles and piles. Nipa palm from mangrove forests produces alcohol which can be processed into fuel. Other natural indirect products harvested in mangrove forests include crustacean, molluscs and fish.

The economies of the rural communities are often based on harvesting wood, fish and other products. Charcoal firewood, poles and piles and fishing industries are based on the mangrove forest resources and provide rural employment.

In addition to the products from mangrove forests, they provide free services, such as wind and storm protection, erosion control, wastewater clean-up and a variety of educational and leisure activities.

Mangrove forests can be managed on a multiple-use and sustained yield basis where the above-mentioned uses of the mangrove can compliment each other.

The mangrove tree is a prolific annual seeder and its seeds are easily dispersed naturally by means of water movement. In artifical regenerations, mangrove seeds can be raised in the nursery or directly planted out in the field. Many mangrove forests have been harvested for a long time on a sustained yield basis.

Mangroves are threatened throughout the world by the traditional users exceeding the sustainable yield limit in the harvests, and by conversion activities such as fish ponds and residential developments. Both over-harvesting and conversion activities can result in severe socio-economic consequences for the coastal rural people and to the country as well.

Extension education programmes, where people are informed of the benefits of mangrove and its sustainable uses may be helpful in the effective management of mangroves. Moreover, the rural people should be deeply involved in the harvesting, utilization and protection of the mangrove. Anybody directly benefitting from the mangroves should be involved in maintaining the sustained yield.

In the study, harvesting is mostly manual and labour-intensive. It was only in the final harvest that a chainsaw was used for felling and bucking. However, where chainsaw are too expensive or not available, bowsaws or other cutting saws can be used.

Rural people can adapt to the harvesting methods employed. However, it is recommended that the other harvesting and helping hand tools be tested, such as the felling lever, log tongs and the log pick, which facilitate felling and handling heavy and slippery newly debarked billets. The wheelbarrow used in minor transport of billets can be further improved.

The living conditions in the harvesting area are arduous and harsh. Better living quarters for the workers would be an incentive. Other incentives could be generated in the form of other sources of income such as fishing in the mangrove ecosystem.

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M-37/T0059E/1/2.89/3000
ISBN 92-5-102755-2