Australian Government
Australian Centre for International Agricultural Research

ENHANCING KEY ELEMENTS OF THE VALUE CHAIN FOR PLANTATION GROWN WOOD IN LAO PDR

Optimal processing equipment for small-scale sawmilling - portable sawmills

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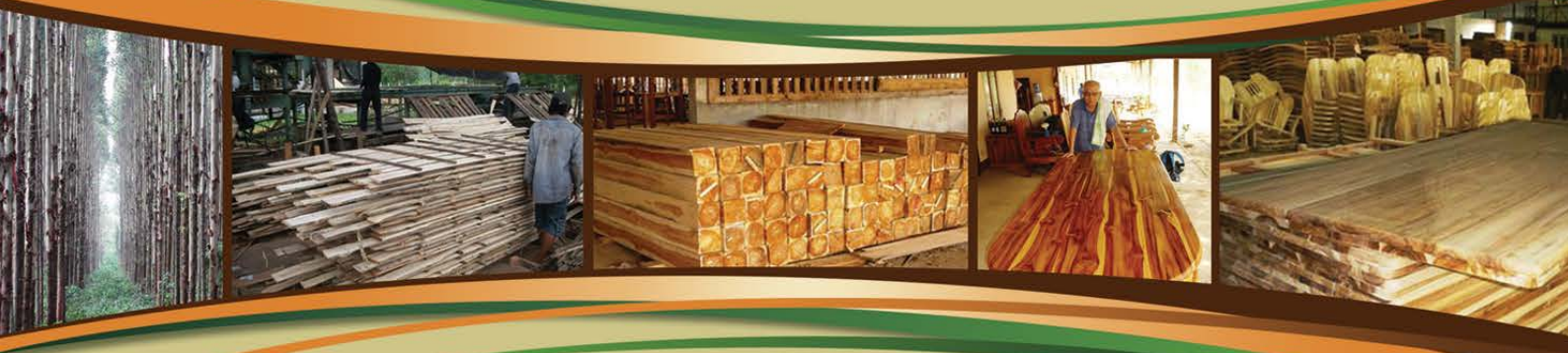
May 2014



VALTIP2

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1. Introduction

This report is a milestone report within Activity 2.6 of ACIAR co-funded project "*Enhancing key elements of the value chains for plantation-grown wood in Lao PDR"*. The objective of the project is to boost the competitiveness and capacity of the Lao PDR wood processing industry through the development of an industry-led value-added timber marketing strategy.

The aim of the report is to provide impartial and independent advice to the Lao PDR wood processing industry regarding appropriate primary processing equipment which is best suited to the local industry. The major focus of the report is on portable and mobile sawmills best suited for small log processing. Obtaining good productivity with a small log is problematic, because the time required to handle one small log far outweighs the quantity of timber that can be produced from it when compared with a much larger log (De Lasaux *et al*, 2004). However, there is the potential for portable sawmills to significantly narrow this gap through value adding to products from small forest plots. The portable sawmill concept has been around since the late 1960's and was first demonstrated in Brazil in 1968 (Smorfitt, 1999). The notion of "portable" can be a loose one and may simply mean the mill is manually loaded (after initially being dismantled) onto the back of a truck or utility and transported to the logging site. Other mills come integrated with a custom-built trailer and remain on the trailer while being operated. This represents more the mobile concept. However, many of these trailers are available as optional extras and do not come as a standard package, translating to an additional cost.

The report is a combination of Dr. Henri Bailleres' (Forestry Science, DAFF Qld) observations at LIGNA, a world-leading trade fair for wood-processing and associated industries and a review of the literature on portable sawmilling equipment. Numerous user-oriented special presentations, seminars, symposia, and international contact exchanges and conferences encompass LIGNA. The Trade Fair was held at Hannover, Germany in 2013 and occurs every two years. Exhibitors from all over the world showcase their latest products and technologies in the areas of forestry, sawmill technology, solid wood processing, wood panel and veneer production, wood crafts and furniture manufacturing. The visit enabled Dr. Bailleres to view the latest in portable sawmill technology and to source information relevant to the application of such technology to the Lao PDR wood processing industry. Portable sawmill technology has the ability to increase returns to processors and forest owners through improved efficiencies of the primary wood processing sector at lower capital expenditure than that required for traditional fixed sawmilling equipment.

The basic concept of sawing is to reduce a log of circular cross-section to rectangular sectioned pieces. To achieve this is not difficult but to do so with maximum efficiency and minimal waste presents the challenge (Rural Solutions SA, 2010). A large industrial milling operation generally requires large volumes of wood of uniform log dimension to be commercially viable. There is a high level of capital investment in equipment, high rates of production and there needs to be a guaranteed volume of log available before a harvesting operation can be considered worthwhile. Portable milling operations, well suited for small-log low-volume processing, represent a balance between business productivity and capital outlay.

This co-funded project is concerned predominantly with Lao teak (*Tectona grandis*) sourced from plantations and a small amount from government quota -controlled natural forests. Log diameters range from 15 - 45 cm with lengths in the range of one to two metres.

In most cases the handling and manoeuvring of logs is done manually without the aid of machines or hydraulics so this will have a bearing on the size of logs that can be processed with the aid of portable sawmill technology. Portable sawmills may represent a viable economic solution for Lao PDR smallholders to process logs which may have otherwise remained uneconomical to process (Rogers, 2010).The most appropriate portable sawmill will be a trade-off between cost, durability, ease of portability and assembly and the best technology available to carry out the processing effectively and efficiently. Durability is extremely important because the mill will spend a considerable amount of time exposed to the elements, particularly heavy rainfall and hot humid conditions in Lao PDR. The most durable mills are those constructed from costly high-gauge, heavy grade powder-coated or galvanized steel.

Portable sawmills have a number of advantages over fixed industrial sawmills (Rural Solutions SA, 2010), including:

- ability to supply niche markets not serviced by larger processors
- value adding for the smallholder grower
- flexibility of milling operations – can move to where the resource is located, greatly reducing transportation costs
- facilitates operations in inaccessible sites
- allows recovery of small volumes of timber economically – this would be is of particular interest for Lao PDR where small woodlots of teak exist
- portable sawmills can handle small diameter logs
- portable sawmills are not as demanding in terms of technology as fixed-site sawmills

However disadvantages exist, including:

- relatively low productivity – this may be negated by the fact that some areas are not being logged at all due to there being no processing facility nearby
- high labour requirement – the Lao people have a strong work ethic so this may not be an issue as much is done manually already
- can involve heavy manual handling operations – “as above”
- the work environment may not conform to proper health and safety regulations
- there may be wide variations in timber dimensions and surface finishes dependent on the standard of the technology being used

It would appear on quick reflection that the advantages override the disadvantages when it comes to the adoption of portable sawmill technology for the Lao PDR wood processing industry though many unknown variables may mitigate against this.

2. Portable sawmill types

Portable sawmills are light and compact compared to stationary industrial sawmills and use either a band or circular blade and guide system to cut logs into boards, square timbers, or cants (Esch, 2013). They are transported either in the back of a utility or truck, on a trailer, or they may have their own trailer axle and hitch. Numerous portable sawmills are available on the market and they usually fall into one of four major categories as discussed below.
Note: All prices quoted are listed in US$ and the figures are approximate only based on the literature reviewed and the exchange rates dated 29 April 2014.

2.1 Portable chainsaw sawmill

A chainsaw mill can be as simple as a metal guide mounted to the bar of the chainsaw that follows a track mounted to the log (Fig. 1). Alternatively, a chainsaw can be mounted to a frame that runs along a track similar to the track system on a band sawmill. The chainsaw would normally be fitted with a special ripping chain.

Figure 1: A Westford chainsaw mill (www.westfordmills.com.au)

The main advantages of a chainsaw mill are portability and cost. They are used for sawing small volumes but are labour intensive, messy (sawdust) and the recovery of material is low with generally limited accuracy. The kerf dimension (kerf is defined as the width of material that is removed by the sawing process) on a chainsaw mill is generally 10 mm larger than that found in a mill using a break-down bandsaw, where the kerf is approximately1.5 - 3 mm. On average, a portable chainsaw mill produces approximately 60 to 120 lineal metres (LM) of timber per day.

A very basic chainsaw mill will cost around $200. More expensive models can range up to $1,500 for a mill that has a track and a frame to which the chainsaw is mounted. These figures exclude the cost of the chainsaw. To operate the mill effectively at least a mid-sized chainsaw is recommended. Depending on the make, model and size suitable chainsaws can range anywhere from $300 to $1,500.

2.2 Portable band sawmill

This type of portable sawmill has a saw head that is guided by tracks set on the frame of the mill (Fig. 2).The log is loaded onto a stationary log bed and the saw head is pushed across the log (either manually or controlled automatically) to perform the cuts.
The band sawmill uses a looped metal band saw blade. These type of portable sawmills usually use a small 25 - 38 mm width band saw blade.

Base model mills are usually driven by a petrol engine in the 12-25 horse power (hp) range, while professional models can be diesel powered and up to 65 hp.

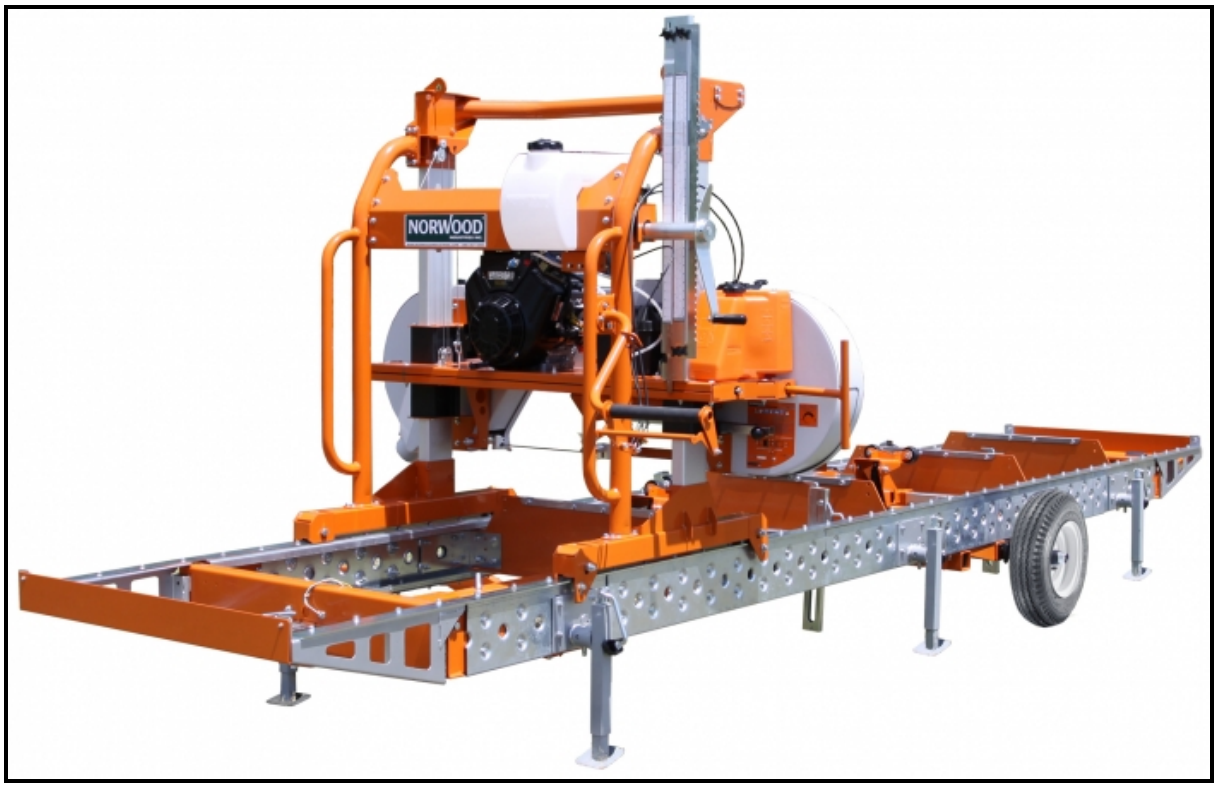

Figure 2: Norwood LumberMate Pro portable band sawmill (www.norwoodsawmills.com)

A major advantage of band sawmills is their thin kerf compared to a chainsaw or a circular blade mill. This means a bandsaw mill provides the best recovery when converting logs into timber (Trees 2 Money, 2013). Saw blade kerf is usually about 1.7 mm which increases recovery by approximately 15% when compared to a circular blade sawmills. These mills are relatively safe to use and logs can be turned on these mills with relative ease. They require about one-quarter to a third of the power needed to run a portable circular sawmill. The user is able to recover grade material from the outside of the log and make a square beam from the heart. On average, a bandsaw mill can produce 250 to 600 LM of timber per day, depending on the make and model (Esch, 2013) Output recovery depends considerably on the log size, tree species and products being cut.

Most band sawmills are aligned horizontally which causes some disadvantages. For instance, as every board or slab has to be removed from the top of the log two passes are required to produce dimensional timber. This can be labour intensive, particularly with the low-tech non-automation models. Sawdust will always be present on the top face which makes it difficult to immediately visually grade the timber. As well, blades require frequent setting and sharpening reducing overall profitability. Blades have a greater propensity to wander and drift than circular saw blades and the cut may not run straight.

Portable band sawmill output is approximately 120 to 300 LM between each sharpening (Nix, 2013). If the operator doesn't have a blade sharpener (approximately $3,500 each), then the blades have to be removed and sharpened offsite.

This may be problematic depending on where the mill is being used. Blades can only withstand five or so sharpenings before they have to be replaced. Blade costs run to about $15 - 20 per 300 LM of sawn timber. Dirty logs and other imperfections in logs increase blade wear.

Band sawmill costs range from around $2,500 for low tech models up to $35,000 or more for fully automated hydraulic models. However, optional extras can add significantly to the base cost. For low tech models, a track is set down and the log rolled onto it. The band blade is pushed through the log. Higher-end mills include automatic feeds and hydraulics to safely secure the log. Generally, band sawmills are safer to operate than circular or chainsaw mills. Some operators (especially among those using circular saw mills) tend to believe that only the higher end models are worthy of consideration (www.procutportablesawmills.com).

2.3 Portable circular saw-swing blade sawmill

A portable circular saw-swing blade sawmill consists of a saw head that runs on tracks mounted to the frame and works similar to a band sawmill (Fig. 3) The main difference is a circular blade mill can cut while the head is pushed and pulled which means dimensional timber can be sawn on either pass. The swing blade mill represents a variation on the circular sawmill. It has a small circular blade, usually 45 - 50 cm in diameter (the teeth are tipped with carbide), that cuts horizontally and then is swung to a vertical position to make the return cut. This innovation increases production significantly. Swing mills generally offer a slabbing unit. This is basically a 1.5 m chainsaw bar that will cut slabs if required. Throughout the report any portable circular saw and/or circular saw-swing blade mill will be simply referred to as a “portable circular blade sawmill” for ease of description.

Figure 3: Peterson Sawmills ATS portable circular swing blade sawmill (www.petersonsawmills.com)

Advantages of a portable circular sawmill include the ability to edge the timber before the final cut saving re-cutting time. Blade cost is fairly low and sharpening can be done on site. Less blade sharpening and maintenance is required compared to a portable band sawmill. Peterson brand circular blades are reported to last two to six years with normal use and maintenance (see www.petersonsawmills.com). After 30 sharpenings or so a new set of teeth costs approximately $30 and takes generally a half an hour to install. This type of sawmill has blade kerfs sitting between that of a band sawmill and a chainsaw mill. The kerf ranges from 5 - 10 mm. Compared to portable band sawmill this means less timber and more sawdust from an individual log. There is a limit to the size of boards and beams that can be sawn. Typical portable circular blade sawmills can produce around 450 to 900 LM of timber per day depending on log size, species and products being cut.

Prices for portable circular blade sawmills can range from $6,000 up to $40,000 depending on the model and any optional extras (Esch, 2013). Historically, the mills retain their value very well. A well maintained used-mill can sell for anywhere between 70% and 90% of its original value. Portable circular blade sawmills have been the machines of choice for the customary forest resource owners in Papua New Guinea and the Solomon Islands (Holzknect *et al.,* 2012).

2.4 Portable dimension multi sawmill

Portable dimension multi-sawmills are multi-saw “portable” mills. They have one horizontal circular blade and one or two vertical circular blades (Fig. 4).
The blades saw the width, depth and length dimensions simultaneously. The three blades allow the log to be completely sawn with minimum edgings and slabs.

Figure 4: Mobile Mfg. portable mobile dimension sawmill (www.mobilemfg.com)

The advantage of this type of portable sawmill is that a dimension cut can be performed that will produce a 100x 50 or 150 x 50 mm cross section in one cut. These units quite often have large motors and are not as portable when compared to other portable mill types. The advantage of these mills is the use of an automatic feed system negating the need to push the saw through the cut. The operator remains in the one position at the head of the mill, controlling the complete operation and the size of the timber being cut. On the return, a dimension system brings the finished timber to the operator.

As with other portable circular blade sawmills, saw blade maintenance and cost is relatively low, since sharpening is performed on-site. With the addition of a specially made trailer up to 18 m long logs can be milled. The disadvantages of using this sawmill type include turning logs, maximum board size and a relatively wide kerf as is the case with other circular blade mills.

These type of portable sawmills are capable of producing 600 to 1,200 LM of timber per day, depending on log size, tree species and products being cut. Because of the increased complexity of these mills the price of a mill can be upwards of $50,000. A second-hand mill in good condition can be purchased for around $30,000. (www.machines4u.com.au).

3. Key considerations in choosing a portable mill

3.1 General considerations

To make an informed choice on the most suitable portable sawmill for a given application there are five general key questions that need to be considered (Edmeades, 2004):

1. What is the business? With the Lao PDR wood processing industry it may be either a small business or a larger commercial operation.

2. What is the market? What will the sawn timber predominantly be used for?

3. Where is the supply? Where will the logs come from and will it be a dependable, continual supply? The size and species will determine blade choice and mill dimensions.

4. Economic considerations need to be determined. For instance, what are the on – going costs? Costs such as log transport, fuel, repairs and maintenance on the mill are of considerable importance. The cost of spare parts such as saw blades and chains as well as the availability of generic rather than brand-specific spare parts can be key considerations.

5. Where are the logging sites? Although portable (and there are degrees of portability) many mills will remain at the same site for an extended period of time and be exposed to all the variables (especially weather) of that site. Powder coating or galvanized metal components will prevent a mill from rusting but can increase cost. Other site specific questions and considerations include:

    - Where will the timber be stacked, stored or dried or will it be transported immediately?
    - Will the area get muddy and washed out?
    - Will trucks have easy access?
    - Is it protected from theft and vandalism?

3.2 Technical considerations

Portable sawmill manufacturers are many and varied. There are nearly 80 brands of mills represented and sold in the United States and Canada alone. Every potential buyer has a unique set of specifications that will determine how much of the mill's capacity is actually needed and what type of a mill should be purchased. These specifications influence the price, the accessories, and design of the portable sawmill (Nix, 2013).

1. What will the portable saw be cutting?

It is very important to determine the log size and product to be cut before selecting a mill. A mismatch of mill to log and/or products can be cost inefficient and result in increased waste of raw material.

The log diameter and length of the average tree to be logged should determine the size of mill to be purchased. A mill designed for large logs may not handle small logs with the same efficiency. The expense of a larger mill may not warrant the actual requirements of the milling operation. This will be an important consideration for the Lao PDR wood processing industry. On the other hand, a mill too small can be easily damaged by large logs and will waste both time and valuable wood. Mismatched mills can also be dangerous to operate.

The products and tree species that will be cut also need to be considered. As discussed, chainsaw mills generally have a kerf of about 10 mm; circular sawmills have a kerf that ranges from 5 to 10 mm and bandmills have the smallest kerf of between 1.5 to 3 mm.

2. Size of the logging operation

Total mill production (output) is a major factor when deciding what type of portable sawmill to purchase. A commercial milling operation needs capacity capability to meet production requirements. In most cases a circular saw portable sawmill would be chosen for production efficiency. However, band sawmills are more efficient in terms of recovery due to reduced kerf and can saw as much as 20% more wood out of a single log than circular saws (Nix, 2013). Unfortunately, all but the most expensive band sawmills are slow producers and may not be suitable if production capacity is the key performance indicator.

As a common rule, the price paid for a mill is in direct proportion to the production capacity of the mill. Generally, the less expensive the mill the lower the production. New portable sawmills range in price from less than $4,000 to over $80,000 depending on the amount of production required.

3. Hydraulics

Hydraulics make sawing easier and faster and definitely less labour intensive but add thousands of dollars to the cost of a sawmill. For some operators hydraulics are absolutely necessary because they minimize log-handling time which increases production and safety. The degree of mechanization is an important consideration, but comes at a cost, including initial outlay and on-going maintenance and replacement costs. Breakdowns in hydraulic equipment in remote locations can cause considerable down-time.

4. Accessories

Most portable sawmills come with a range of accessories. These accessories add extra costs to the sawmill. Their necessity needs to be gauged against the type of operation. An automatic sharpener/setter system for band blades normally costs a couple of thousand dollars. Some operators find that sharpening their own blades is the most cost effective way to run the mill; some send their blades to a sharpening service; some operators simply dispose of the blades after 4 or 5 hours of use. The production requirements of the portable mill will determine which is the most appropriate of the three options.

3.3 Portable band sawmill examples

Band sawmills lead portable mill sales in North America. Below are the choices and price ranges of popular band sawmills currently on the market in North America (Nix, 2013). Band sawmills were chosen because the information was readily available when compared to other types of portable sawmills. Specific prices for other types of portable sawmills are listed later in the report.

- **Manual:** The least expensive. They have no labour-saving hydraulic features which increases the amount of work the operators must do. New models with a trailer package generally cost between $4,000 and $9,000.

- **Power feed:** The blade is mechanically powered into the cut, but the operator must load and turn the logs manually. New models with a trailer package generally cost between $9,000 to $14,000.

- **Fully hydraulic:** This category of portable band sawmills features the most labour-saving devices that minimize the workload and maximize production. The more expensive models normally have larger power units and other accessories designed for higher daily production. New models with a trailer package generally cost between $16,000 and $32,000.

- **High production:** These mills are designed for professional operators and normally require a high level of expertise. They offer specialised features designed for higher production sawing, such as high-powered engines, wider bands, and more productive log and timber handling equipment. New models with a trailer package generally cost between $35,000 to over $100,000.

4 Portable sawmill exhibitors at Ligna 2013

4.1 Enercraft-Baker

Enercraft-Baker (www.baker-online.com) stock a range of portable band sawmills from the Baker 18M to the Baker Blue Streak 3665D with increasingly more sophisticated and costly technology (including hydraulics). One of their more popular models is the Baker 18M portable band sawmill (Fig. 5).

Figure 5. Enercraft-Baker 18M portable band sawmill (www.baker-online.com)

This mill is affordable and reportedly very easy to operate. Blade height adjustment is made using a simple hand crank with chain and reduction sprockets. A brake locks the blade in place while sawing. Logs are sawn by pushing the carriage manually down the length of the track. When the cut is finished, the blade is cleared and the carriage pulled back to the starting position. The Baker 18M portable band sawmill model is powered by a 20 hp petrol engine. The mill is designed to saw logs up to 75 cm diameter x 4.8 m in length.

Baker Blue Streak 3665D portable band sawmill is the company's top of the range model and is built to handle large logs and industrial scale sawmilling. The mill has been enhanced with a 50 mm band blade and a 65 hp diesel engine. The head is raised and lowered equally on both sides with a computer-controlled, hydraulically powered system.

Enercraft-Baker products have been sold to approximately 60 countries worldwide including Indonesia and Malaysia and the company reports they are able to ship replacement parts with a minimum time delay.

4.2 Wood-Mizer

Wood-Mizer (www.woodmizer.de) is one of the largest sellers of portable band sawmills in the U.S. The company has been operating for over twenty years producing thousands of portable sawmills. Wood-Mizer offer two small personal sized mills and four larger sized models for increased production using larger logs. Wood-Mizer is the only manufacturer that uses a single post, cantilever design for their mills(Fig. 6).

Figure 6: Wood-Mizer LT 15 portable band sawmill (www.woodmizer.de)

The design feature allows the cutting heads to travel the length of the log along a single track with an accuracy that reportedly cannot be matched by twin-rail systems which require a perfectly level ground. Since the cantilever sawmill head is always parallel to the bed, the sawmill does not have to be perfectly level, minimising site preparation time. The design allows the mill to be set up and dismantled in just a few minutes..

This single post design allows the Wood-Mizer to handle logs that are bigger than other frame designs and logs do not have to be manipulated between two or more posts. In addition, this type of design allows odd shaped logs to be more easily accommodated.

However, among some users, there still exists a preference for two to four post designs due to the belief that the Wood-Mizer is unstable because it uses only a single rail. Wood-Mizer also offer two post systems to accommodate users that prefer this design. The portable mill is designed for low volume production, particularly where logs are to be sawn for furniture production. The blade of the portable saw is narrower than those used on big stationary mills.

Prices start at around $5,500 with a 13 hp recoil-start petrol engine. A trailer package, larger engine, bolt-on bed extensions and other optional extras are available.

4.3 Serra

Serra (www.serra.de) is a German manufacturer of portable band sawmills. They offer a wide variety of equipment options depending on the size of the logging operation and the resource to be logged. (Serra produce the Alpina KE90/KB90 (and the Montana MD90/ME90 models which are both able to process logs up to 90 cm in diameter (Fig. 7).

Figure 7: Serra Alpina KE90 portable band sawmill (www.serra.de)

The Alpina KE 90 is best suited where the main requirement is for the lowest possible investment. It has a 35 hp petrol engine. The hydraulic capacity includes a two log lifter, a log clamp turner, two levellers and four clamps to hold the log. The Montana MD90/ME90 is the preferred choice for robustness and better quality with more automated sawing. It is also equipped with a hydraulic drive and the entire structure is galvanized for extended durability outdoors. It is equipped with a stellite tipped blade that stays sharper for longer, reducing maintenance and down time. Stellite is a combination of cobalt chromium alloys which is very wear resistant. It may also be made up of tungsten or molybdenum with a small amount of carbon.

4.4 Logosol-Norwood

Logosol-Norwood (www.logosol.de) is a Swedish based company currently servicing 65 countries with portable band sawmills, and are regarded for simplicity of design, reliability and efficiency. In North America Logosol trade under the brand name Norwood. The Norwood LumberMate Pro is one of their more recent portable band sawmill designs (Fig. 8).

Figure 8: Norwood LumberMate Pro portable band sawmill (www.logosol.de)

The band wheels are cast in steel, and are quite large being over 500 mm in diameter. The blade is led through the log by double sets of ceramic blocks above, below and behind the blade; a standard today on industrial stationary band sawmills. The result is reportedly a band sawmill that cuts more precisely at a greater speed. The band sawmill can saw logs up to 90 cm in diameter. Norwood supply both petrol and electric models of the LumberMate Pro and they are equipped with automatic water cooling systems. For safety and faster head returns, the sawmill is equipped with a saw brake that quickly stops the saw band after every cut.

The saw motors and the feeder unit can be operated from the control panel located at the end of the guide rail. Feed pressure is adjustable and feed rate is automatically adjusted to resistance providing comfortable sawing while maximizing sawing speed. The board is lifted from the cant by a pair of brackets when the saw is reversed, and is then placed in a stack next to the operator. Prices for the LumberMate Pro range from $5,000 to $10,000 but there are a large number of optional extras which can considerably add to the cost.

4.5 Avangard

In 1999, in partnership with a Swedish company Hakansson Sawblades, a manufacturer of bandsaw blades, Avangard (www.pilorama.ru) began producing the LP-80 portable band sawmill which has been used in almost all regions of Russia, with approximately 2,000 machines being produced to date. The reported advantage of these portable sawmills, as opposed to other manufacturers, is a saw transverse design ensuring two-support fastening of the saw pulley shafts reducing the load on the machine. The improved Avangard LP-80 S.E.N. has a portal-type movable carriage which gives rigidity and limits vibrations during sawing (Fig. 9).

Figure 9: Avangard LP-80 S.E.N. portable band sawmill (www.pilorama.ru)

The mill has a telescopic-type saw with a two-support fastening system for the saw pulleys and a hydraulic bandsaw tensioner which moves over a number of precision cylindrical guides. Bandsaw support during cutting is provided via slot clearances fitted with plates ensuring accurate positioning and decreasing the noise level during sawmill operation. The mill is controlled from a console mounted on the movable carriage frame. The console is equipped with an electronic ruler which programs the thickness of boards to be removed and a manual ruler for visual monitoring.

4.6 Pezzalato

Pezzolato (www.pezzolato.it) was founded in 1976 in Italy. The Timber Queen HD 7 model portable band sawmill is one of the company's cheapest totally hydraulic short-blade portable sawmills (Fig. 10).

Figure 10: Pezzolato Timber Queen HD 7 portable band sawmill (www.pezzolato.it)

Power options include either a twin-cylinder petrol or a four-cylinder diesel engine. It is possible to equip the machines with extensions for cutting log lengths up to 12 m. Control of the portable sawmill is managed by a specific panel at the front of the machine. All functions of the head and handling of logs such as log grip, log turner and log leveller are hydraulic and included in the standard sawmill package. All the sawmills are equipped with a two armed loader and trailers for towing.

5. Portable sawmill manufacturers – other

There are a number of other portable sawmill manufacturers who were not present at Ligna but are worth mentioning in the context of this report, especially as it includes a number of portable circular blade sawmill models which may be well-suited to the Lao PDR wood processing industry.

5.1 Hud-Son Forest Equipment

Hud-Son Forest Equipment (www.hud-son.com) is an American based company. specializing in portable sawmills, bandmills, and sawmilling equipment. The Hud-Son Oscar range has four models which between them can handle logs from 45 -90 cm in diameter (Fig. 11).

Figure 11: Hud-Son Oscar 121 portable band sawmill (www.hud-son.com)

All four Oscar machines feature a four post design for maximum head stability and they can be supplied as a towable trailer package. The Oscar 121, one of their most portable and cheapest band sawmills, comes standard with a 16 hp engine, cuts up to 50 cm diameter logs, has log guides and has a welded angle iron track. Prices begin around $5,000 for the base model.

5.2 TimberKing

TimberKing (www.timberking.com) is an American company producing portable band sawmills. TimberKing's B-20 mill (1989) was the first portable mill with a four post cutting head including hydraulic chain log turners, hydraulic vertical log stops, standard computer set-works and hydraulic roller toe boards. After many iterations and innovations, such as the inclusion of hydraulic log loaders, the TimberKing Model 2000 was introduced in 2009 (Fig. 12).

Figure 12: TimberKing 2000 portable band sawmill (www.timberking.com)

The Model 2000 offers a more advanced computer set-works, wider cut throat and direct-action hydraulics. It uses a 25 hp Kohler engine. TimberKing band sawmills use a four post head frame to provide consistent alignment between blade and log deck. The one piece welded frame and saw head are powder-coated for prolonged durability in the outdoor environment. A trailer package, larger engine, bed extensions and other options are available. Costs start at around $5,000 - $6,000 for the base model.

5.3 Lucas Mill

The Australian Lucas family established Lucas Mill Pty Ltd (www.lucasmill.com) in March 1994. To date over 13,500 machines have been sold into over 100 countries around the world. The portable sawmill uses a circular swing-blade and is designed to suit the harvesting of both hard and soft timber species and can be reportedly operated on any terrain (Fig. 13).

Figure 13: Lucas Mill portable circular saw - swingblade sawmill (www.lucasmill.com)

Lucas Mill was established with the objectives of developing a portable timber-milling machine that was:

- simple to operate,
- affordable without compromising quality, and
- versatile and durable to be used in the harshest environments.

The versatility of these mills provides operators with the ability to cut both small and large boards to specific dimensions, whilst minimising wastage. The Model 8-30 is currently the most popular choice in the Lucas Mill range. Side shift winder and track extensions are included as standard with this model. A full range of optional accessories are also available. Cost of the latest models start at around $15,000 depending on optional extras.

5.4 Peterson Sawmills

Peterson Portable Sawmills (www.petersonsawmills.com) is a New Zealand company producing circular saw - swingblade portable sawmills. The Peterson range of sawmills was originally designed to be used in the jungles of Fiji, and thus were designed for portability and durability. The All Terrain Sawmill (ATS) can be set up in remote locations on uneven surfaces (Fig. 14).

Figure 14: Peterson ATS portable circular saw – swingblade sawmill (www.petersonsawmills.com)

Peterson Portable Sawmills' claim that their swingblade sawmill is more versatile than portable band sawmills. The operator is able to cut different dimensioned timber out of one log, while still being able to use the double-cut feature or a clip-on slabber (with large frame mills only) to cut wide boards. Peterson mills are designed to be efficient when using the mill from log to log, as well as when permanently set up at a fixed site. Setting up the mill around a log normally takes 10 - 15 minutes. Alternatively a stockpile of logs can be placed on skids and rolled into the mill. The mill can be disassembled and loaded onto a small trailer or utility in around 5 - 10 minutes. Peterson sawmills claim the mill requires only a one-half day of training to equip the operator with the necessary skills of use.

There is no requirement to double-handle timber when it has been cut with a Peterson portable mill. The circular saw blades reportedly require far less maintenance than band saw blade counterparts and the operator can sharpen them on the sawmill in under 5 minutes. Peterson portable sawmills use a MicroKerf blade with 3.5 mm kerf tips; the smallest available in today's market .These MicroKerf blades are said to increase cutting speed by 20-30%, while also increasing recovery by 15-20%.

A number of Peterson sawmill models exist ranging from the Peterson All Terrain Sawmill (ATS) and the Peterson Automated Swingblade Mill (ASM). The ATS mill has been designed for remote locations with uneven ground. The ATS uses a raised track system, and tracks are raised and lowered with winches at the operator's end to adjust the cutting height. The Peterson Automated Swingblade Mill (ASM) can make horizontal and vertical cuts, change the size or depth of the cut, and remove the previously cut board, using controlled automation. The ASM was designed with high production in mind and can maintain fast and consistent production throughout the entire milling process. The ASM can be operated with a board remover add-on which can return the

milled boards to either end of the mill. This is useful for single person milling as it allows the operator to maintain high production rates.

5.5 Sawmills New Zealand

Sawmills New Zealand (www.sawmills.co.nz) produce portable twin-saw circular blade mills under the Mahoe brand name. The Supermill model has vertical and horizontal tungsten-tipped blades and is powered by a 42 hp Kubota turbo diesel engine (Fig. 14). The travel feed is friction drive but there is a hydraulic option. The rise and fall is hydraulically operated.

The Minimax model is a cheaper, lighter sawmill. It has fine kerf blades and log dogs to hold the log firmly. The chain block rise and fall is easy to use and accurate with the dial gauge large and visible. The Minimax packs down onto a custom built trailer and is easy to tow behind a standard sized utility or truck.

Figure 14: Mahoe Supermill portable circular blade sawmill (www.sawmills.co.nz)

5.6 D and L Timber Technologies

D & L Timber Technologies (www.dltimbertech.com) is a Canadian company producing circular saw swing-blade portable mills (Fig. 15). They use thin kerf carbide tipped circular saws and offer sawmills for many cutting applications and production needs. The D&L swing blade utilises a 180 degree swinging circular saw giving it a number of claimed advantages over 90 degree swing counterparts.

These advantages include:

- saw guards swing with the saw protecting the operator at all times
- double cutting is easy
- guards remain in place at all times
- the head does not have to be removed and turned 180 degrees to cut back
- the operator can cut from either side of the log
- large beams up to 250 x 500 mm, can be cut without log turning

D&L sawmills use stainless steel components providing longevity, strength and performance. The D&L swing blade uses a D&L carbide-tipped thin kerf 5 mm blade. Sharpening can be performed without removing the blade using the standard 12 V diamond sharpener and jig. The D&L swing blade mill can be transported by hand to the log.

Figure 15: D & L Timber Technologies portable circular swingblade sawmill (www.dltimbertech.com)

Note: The search for Chinese-made portable sawmills which may be suitable for the Lao PDR forest industries was limited. The Shouguang Sunrise Industry Co. Ltd (www.sunriseproduct.on) produce a number of portable band and circular sawmills but obtaining sufficient detail on the specifications was difficult to locate. Most searches direct you to “e-bay” type sites and not manufacturers’ sites. Their portable band sawmills with diesel engine power were listed at $6,000 - $15,000 each. They also produce a portable circular blade saw with a similar size engine but prices were again difficult to find.

Summary

Table 1 provides a comparison of some of the important features pertaining to a selection of well-known portable band sawmills manufactured in the USA and Canada but generally available worldwide. This information is provided by Woodland Mills and additional information can be sourced at www.woodlandmills.ca. Prices are indicative only and may vary markedly depending on the choice of optional extras and level of technology.

Table 1. Comparison of some important features of a selection of well-known portable band sawmills from the USA, Canada and Europe.

Manufacturer	Price	Model	Engine	Max Log Diameter	Portability
Woodland Mills 	$2,899	HM 126	Kohler Command Pro 9.5 hp petrol engine	66 cm	Requires a two wheel trailer sold separately – cannot be shipped
Hudson 	$2,799	HFE 21	Briggs & Stratton 6.5 hp petrol engine	54 cm	Would need to be loaded onto a ute or truck for transport
Hudson 	$3,799	Oscar 121	Briggs & Stratton 10 hp petrol engine	54 cm	Would need to be loaded onto a ute or truck for transport
Woodmizer 	$3,795	LT10	7 hp petrol engine; optional 10 hp available	61 cm	Would need to be loaded onto a ute or truck for transport
Norwood 	$5,197	LM29	Kohler 14 hp petrol engine	66 cm	Can be loaded onto a two wheel trailer sold separately
Baker 	$3,900	Wood Buddy	Honda 9 hp petrol engine	70 cm	Can be broken down and loaded onto a ute or truck
SMG Champion 	$3,995	Little 9.5	Kohler 9.5 hp petrol engine	66 cm	Can be loaded onto a two wheel trailer sold separately
Cook's Saw 	$5,995	MP- Kohler 32	Kohler 12 hp petrol engine	80 cm	Comes with a permanent integrated trailer - optional extra cost

Manufacturer	Price	Model	Engine	Max Log Diameter	Portability
Woodmizer 	$7,095	LT15	Kohler 18 hp petrol engine	71 cm	Can be loaded onto a trailer – two trailer packages sold separately
Timberking 	$6,500	1220	Kohler 15 hp petrol engine	85 cm	Optional highway transport package
Clarke 	$6,995	#20	Honda 13 hp petrol engine	76 cm	Two wheel trailer comes standard with the mill
Serra 	$45,000	Alpina KE 90	V2 35 hp petrol engine	90 cm	Can be towed
Avangard 	$6,200	Avangard LP80 - A	Honda 18 hp petrol engine	80 cm	Has to be loaded onto a truck or trailer
Pezzolato 	$7,000	Timber Queen HD 7	Twin cylinder petrol or 4 cylinder diesel	90 cm	Supplied with a trailer

Table 2 provides a comparison of some of the important features pertaining to a selection of well-known portable circular-swing blade sawmills manufactured in the USA, Canada, Australia and New Zealand.

Table 2. Comparison of some important features of a selection of well known portable circular saw -swing blade sawmills.

Manufacturer	Price	Model	Engine	Max Log Diameter	Portability
Lucas Mill 	$14,000	8-30	Kohler Comand Pro V-Twin Closed Loop Electronic Fuel Injection (EFI) Engine.	150 cm	Trailer not standard; easily loaded onto a utility or truck
Peterson Sawmill 	$34,000	ASM	27 – 38 hp Kohler petrol engine	180 cm	Trailer not standard, easily loaded onto utility or truck
Mahoe Sawmill 	$55,000	Supermill	Kubota 42 hp turbo diesel engine	90 cm	Custom built trailer as an optional extra
D & L Technologies 	$20,000	8 X 16 Pro	27 hp petrol engine	120 cm	Transportable with standard mobile dolly wheel attachment
Mobile Dimension Saw 	$46,000	12 XLS	Petrol-powered VW engine 67 hp	Unlimited – any size	Heavy duty stainless steel trailer sold separately

6. Recommendations

6.1 Key considerations

The key parameters and issues to be considered before investing in a portable sawmilling system are:

- Ease of use – an over-engineered mill (increased technology) may not necessarily be beneficial
- Production capacity – lineal metre output per day in relation to the logged species viz. *Tectona grandis* and the input volume
- Durability – resistance to general wear and tear as well as prolonged exposure to the vagaries of the weather especially rainfall – rust resistant structures/coatings should be taken onto account. Additionally, machinery and parts warranties should be scrutinised.
- Sawing accuracy and quality of cut surface
- On-going maintenance and service costs – availability of spare parts (including generic parts) and ability to self-service especially blade sharpening and replacement – availability of service technicians if required
- Portability – ease of transport to the logging site and ease of set-up and breakdown if required
- Reliability – the ability of the mill to perform the task it is required to without excessive breakdowns and/or maintenance
- Cost – can range from $5,000 to $100,000 depending on the type of mill and the technology incorporated into the machine
- Ability to upgrade and add-on optional extras
- Re-sale value
- Operator safety; equipment safety features such as guards and noise abatement.

6.2 Recommendations for the Lao PDR

Although chainsaw mills are the cheapest option, the low recoveries achieved mean that this equipment isn't efficient and results in excessive waste. Portable circular blade sawmills result in lower recoveries than band sawmills, but provide advantages in ease of setting and sharpening, longer blade life and superior quality of cut and higher productivity in hardwood processing.

While portable circular blade sawmills cost more initially to purchase and there is less choice when compared to portable band sawmills, they appear (from the literature) to be more suited to prolonged use and storage outdoors and have less on-going maintenance and service costs. This means less downtime and higher productivity. Circular blades last longer than band blades and can be sharpened in-situ without the need to remove the blade for sharpening or to send the blades away for sharpening.

Circular blade sawmills are capable of cutting more boards per day than a chainsaw or band sawmill taking into account log size, species and products being cut. There is more wastage when compared to a band sawmill, due to the wider kerf, but this has been addressed somewhat by MicroKerf blade systems which reportedly increase cutting speed by 20-30%, while also increasing recovery by 15-20%. There is a limit to the size of boards and beams that can be sawn, but this may not be an issue depending on the types of products being produced and the fact that teak log size is small, generally not exceeding 45 cm in diameter. All circular blade models appear to have good portability with either custom built trailers or the ability to be easily load the mill onto a utility or truck. Portability is a significant issue in relation to the accessibility of the teak resource.

Portable circular blade sawmills have been used profitably in many different countries around the world. Out of 55 portable sawmill operators listed in Australian Woodworker Magazine (January 2014 issue), 75% were using portable circular blade sawmills, while the remainder were using either a chainsaw mill or a band sawmill. The operators were involved in urban forestry and/or timber salvage. This re-enforces the worth of the portable circular blade sawmill. It is clear from the literature that the manufacturers of such mills have well presented and concise websites and additional information on makes, models, features, specifications and technical aspects can be sourced from these sites. Internet forums are also a good place to find user reviews and recommendations based on previous experience.

While a thorough search was conducted in the preparation of this report there will of course be other manufacturers which are not listed here (more likely in the portable band sawmill market) which may have products which are eminently suitable for the Lao PDR wood processing industry. Additionally, internet forums discussing the use, user satisfaction, application etc. of portable sawmills are updated regularly. Potential buyers of portable sawmills are urged to investigate such forums. A simple internet search for “portable sawmill forums” results in a multitude of useful forum sites.

7. References

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