

The potential of chainsaw milling outside forests



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Summary report
with economic and policy case studies from East Africa

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Decision-making framework

- ❖ When chainsaw milling makes sense. Two Microsoft Excel spreadsheets, the first an economic model, the second a policy decision support model.

Training materials (English, French and Spanish)

- ❖ Turning Trees to Timber. A Chainsaw Milling Manual. 40pp.
- ❖ Turning trees to timber: a chainsaw milling poster series. Nos. 1-8.

Policy briefs

- ❖ Chainsaws, milling and regulation. 2pp.
- ❖ Chainsaw milling – improving timber production and rural livelihoods on farms and in drylands. 2pp.
- ❖ The future of powersaw splitting (chainsaw milling) in Kenya. 2pp.
- ❖ The potential of chainsaw milling for improving rural livelihoods in Uganda and DR Congo. 2pp.

Disclaimer

Chainsaws are dangerous and potentially fatal and this must be acknowledged by all users. This manual contains information and best practice recommendations based on sources believed to be reliable. This is supplied without obligation and on the understanding that any person who acts on it, or otherwise changes their position in reliance thereon, does so entirely at their own risk. No liability

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Cover photographs

Top left: mobile 'bench' (circular) saw, Meru, Kenya
Top right: chainsaw 'rail' milling, Baringo, Kenya
Bottom left: chainsaw 'frame' milling, Meru, Kenya
Bottom right: fixed circular saw, Meru, Kenya
All photographs, Nick Pasiecznik

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1 Chainsaw milling in the world

Summary

Common opinions concerning the sawing of logs into boards with a chainsaw include: it is not possible, hardly anyone does it, it is very wasteful, it produces curved boards, and the finish is very rough. A new chainsaw milling manual (Pasiiecznik et al., 2006) may overturn these misconceptions, and allow people to see milling with chainsaws in a new light, as an increasingly common method of producing timber, being cheap and efficient, available to most people, producing quality timber, with appropriate technology already available and just waiting to be applied. Most chainsaw milling is, however, carried out 'freehand', i.e. without the use of any guides, frames or rails that would otherwise help sawyers produce even dimensioned quality boards with less chance of accidents. The few studies on chainsaw milling that do exist highlight the need for further training.

Outside traditional forest zones, e.g. drylands or farmlands, wood from trees provides relatively little income, as fuel, posts or sold standing. Processing logs on-site increases value and revenues to the tree owner and stimulates local economies by provision of raw materials, but low timber volumes and large distances to market mean even small sawmills are often uneconomic. Chainsaw milling has proved valuable in some remote forest locations but is little-known elsewhere where it shows promise. The chainsaw milling with attachments productivity and recovery presented here compare well with portable band saws and circular saws, especially when considering the considerably lower capital cost and ultimate portability of a chainsaw and milling attachment. Using attachments, the timber produced is invariably straight, the finish good, and if using special ripping chains, can be "as good as from any bandmill".

Chainsaw milling is, however, responsible for the processing of significant and increasing amounts of timber in the tropics, both inside and outside forests, legally and illegally, though its use is rarely acknowledged as there are few reliable figures. There is a clear need for more information on the equipment and techniques available, when and how they are used and by whom, and the economic, environmental and social impacts. This project aimed to overcome all these identified constraints, by reviewing chainsaw milling in general and in East Africa in particular, and producing: multi-lingual training manuals, wall posters on the wise use of chainsaw milling, this summary report with a decision making framework, policy briefs, articles for trade journals and newspapers, and an internet site containing all publications and related materials (<http://chainsawgwork.org/>).

The global review provides information from forested areas and temperate regions supporting the view that chainsaw

milling could be economically viable in similar tropical situations, increasing revenues for tree owners, millers and artisans, and reducing negative environmental effects. However, these may not all occur in every situation, especially if the technology is used without control, and the dangers of uncontrolled use are identified and included in the assessment. The example from some other countries indicate that government regulation is unlikely to have much impact on its own, so alternative systems are proposed to mitigate detrimental effects. These are based on ensuring clarity of laws and their enforcement, training and certification type chain of custody,

East Africa was selected as a case study region as portable milling outside forests is already well developed there. A decision-making framework for collecting data and for assessing 'when chainsaw milling makes sense', was undertaken in Meru, Kenya, supported with other studies elsewhere in the region. The formulation is presented, and the different information can be added on the web-based spreadsheets allowing users to adapt it to their own situations and use the framework to collect their own information. Then, whether chainsaw milling is appropriate can be assessed, and recommendations can be made to ensure that its use maximises benefits to rural livelihoods and local environments. Of specific interest is the potential for improving the well-being of people on forest margins, on farms, in drylands and other areas of low forest cover, where low timber volumes and/or poor tree form appeared likely to favour the use of low capital and simple technology timber processing methods.

This report should be of interest to those involved in forest policy, timber production, agroforestry, natural resource management and wood processing, amongst others, whether they are governmental, non-governmental, educational or commercial. It is hoped that this report and associated project outputs will assist in allowing the assessment of when the application of such simple and appropriate technology for converting on-farm, dryland and street trees to marketable timber is appropriate. In doing so, more money should reach the families of tree owners, forest-dependent people or those who work with wood. This may in the long term promote tree planting in such areas with all the consequential environmental and economic benefits.

Training is identified as the single most important need along with general policies of promoting farm timber and processing, clarification and application of timber laws. Training is a large challenge, and one not for extension workers alone, but also in convincing machinery manufacturers and dealers, who will gain from the developing enterprises, that it is their best interest to invest in such knowledge sharing. Also, training is required not just in the use of milling attachments, but importantly also in basic

chainsaw safety, use and maintenance, as well as timber drying and marketing.

In agroforestry, the timber from trees have rarely played significant role in rural incomes, though the need for diversification and the indirect benefits of trees are increasingly encouraging tree production. Turning farmlands and drylands into timber producing areas is realistic, if equipped with the appropriate skills and tools. This will in turn reduce the pressure on natural forests and reduce illegal harvesting. To achieve this though, needs the efforts of many committed individuals at all levels to raise awareness and provide training to ensure that chainsaw milling makes a positive – rather than a negative – contribution to rural livelihoods and the sustainability of farm and forest land alike.

Trees, timber and livelihoods outside forests

The importance of timber production from outside forests is attracting increasing attention, to help meet growing demand and reduce pressure on natural forests and plantations. There is a corresponding and increasing body of literature to support this, notably regarding timber from agroforestry systems (Arancon, 1997; Hanson and Stewart, 1997; Pasiecznik, 1999; ASB, 2001; Holding et al., 2001; Holding-Anyonge and Roshetko, 2003; Holding-Anyonge et al., 2003, Russell and Franzel, 2004; Scherr, 2004; World Agroforestry Centre, 2005) and specifically from drylands (Rogers, 1984; El Fadl et al., 1989; FAO, 1989, Brennan and Newby, 1992; Felker, 2000; Pasiecznik, 2000; Blackwell and Stewart, 2003; Felker and Guevara, 2003, Venn et al., 2003).

In the 1990s, there was much emphasis in research and development on non-timber forest products (NTFPs), including from trees outside forests such as in farm agroforestry and dryland. This was, however, to the detriment of considerations relating to the production of sawn timber (e.g. Pasiecznik, 1999), which finally gave way to an understanding of the role of timber as a product from farms (e.g. Scherr, 2004; World Agroforestry Centre, 2005).

However, recent literature surrounding 'small-holder timber' often concentrates on marketing and commercialisation, acknowledging the critical importance of value addition to tree products. While this is appropriate to the current emphasis on policy and livelihood impacts, practical problems on the ground are rarely addressed. This is especially true of primary timber processing, and the increase in revenues that on-farm milling could achieve have been largely overlooked. One exception to this has been in Australia, where there is an increasing wealth of knowledge on the role of portable sawmilling in timber production from farm forestry (e.g. Hanson and Stewart, 1997; Stewart and Hanson, 1998; Smorfitt et al., 1999; 2001; 2004), with potential application to other countries.

The role of trees as savings banks has been emphasised in agricultural and agroforestry systems (e.g. Chambers and Leach, 1989), especially important in low-income years, during droughts or if prices of commodity crops or livestock products fall, or when cash is required such as for hospital or school fees, marriages or funerals. Shade trees in plantation crops, e.g. *Cordia alliodora* in Central America, *Grevillea robusta* in East Africa and numerous species elsewhere are typical in this regard, and many studies have assessed the production, value and importance of such trees as a source of timber in supporting rural livelihoods. If trees are indeed acting as a 'savings bank' for farmers, then inexpensive portable sawmills could greatly increase the value of their withdrawals from the bank, by adding significantly to the sale price, as sawn timber, way above that paid for standing trees.

A greater quantity, quality and diversity of timber products produced locally is also likely to have secondary effects, possibly stimulating further processing or artisanal activities such as furniture or craft making, transport and the associated trade in tools, materials and equipment. More money to tree owners from the sale of value added timber products and to timber processors will increase local cash flow, the chances for re-investment, and other aspects that would benefit the local economy. Adding value to trees will also improve the chances for more trees being planted and better managed on farms, with the knowledge of the increased returns that can be gained. There are, however, numerous constraints that may prevent such an ideal vision for rural development taking place, though with careful insight, assistance and a suitable policy environment, advances could be made.

Appropriate timber processing technologies

Important aspects to be considered when selecting mill types include: access to timber trees, technical skills, productivity, available capital, availability of mills, labour considerations and end markets. When timber is in plentiful supply, static sawmills are likely to be most viable, with a highly mechanised and efficient operation able to process tens or hundreds of cubic metres of timber per day. Other mills may be 'semi-static', i.e. can be dismantled and moved with some effort, but the time required means that a certain amount of timber has to be milled to ensure profit before changing location again.

Then there are the truly portable mills, generally considered the most appropriate outside forests where trees are scattered, standing timber volumes are low and access may be limiting. It might also be not a straightforward question of 'either or', but of how to best mix several mill types in a single operation. Chainsaw mills are, for example, sometimes used to cut slabs in the forest or other less accessible locations, for transport to a site where the timber is resawn by a bandsaw or circular saw.

Circular saws, band saws and chainsaw are the three alternative sawing systems employed in commercial portable mills. Band saws have the lowest kerf (around 3 mm), and high output, quality and efficiency, but require much expert resharpening especially with hardwoods. Circular saws have a wider kerf (around 6 mm), are more durable and require less expert resharpening, but as they come in so many designs, swing blades, double blades, etc., it is difficult to generalise on their output and efficiency, though hitting nails or stones is costly as blades are expensive. Chainsaws and chainsaw mills are the cheapest, but have the widest kerf (around 9 mm), lowest output and efficiency, with variable quality. Low kerf chains and bars exist, however, reducing kerf to 6 mm, ripping chains improve quality equivalent to that from bandsaws, and chains are also cheap and easy to sharpen.

Wyatt (1996) assessed whether chainsaw milling or portable circular saw mills (the 'walkabout') were most appropriate in the natural forests of Vanuatu, but his conclusions also have relevance outside forests elsewhere in the world. "However, it should also be acknowledged that chainsaw mills are not generally a suitable tool for production of significant quantities of timber, or for a full-time sawmilling business. This should rightly be the role of a walkabout sawmill, with a more efficient engine and sawing system. Chainsaw mill operators who have expanded to a larger sawmill have found that their chainsaw mill was a valuable learning tool, the experience from which significantly contributed to the success of the larger business. However, in Vanuatu, most chainsaw mill operators have not expanded to walkabouts, while some of those who started with walkabouts have 'down-sized' to chainsaw mills. This could be due to lack of resources, to absence of facilities or technical support, or it may simply be because operators feel that their needs are being met by the smaller machine."

What has become increasingly clear over the past decade is that chainsaw milled timber is making up an increasingly significant proportion of locally available timber in many tropical countries. Milling attachments are very rarely used, however, and the 'technology' employed is the most basic, being a hand held chainsaw with a 'chalk line' as the only accessory. This method does have inherent problems related to a high risk of accidents, operator fatigue and poor board finish when using the standard techniques of removing depth gauges and using only the tip of the bar.

Outside of forests, low tree densities and volumes mean many common forestry practices are unviable. Farmers with trees on their land are presently likely to sell them standing, rather than becoming involved in harvesting and processing, and thus receive only a small portion of the value of the tree as sawn timber, with the trader (middleman) and sawmill owner making most of any profit. Sawmilling machinery suitable in situations with such low production must be very portable, able to efficiently cut small diameter, short and sometimes crooked logs, and of low enough capital cost to be economical if milling only a few cubic metres a week.

Chainsaws with milling attachments are used in some tropical moist forest and temperate forest situations, and an increasing number of different types are becoming available. They have certain characteristics and requirements that make them suitable for a limited number of operations in forestry, but show enormous potential for low volume farm forestry, agroforestry and dryland applications (Pasicznik, 2000).

Chainsaw milling equipment

The following is a description of equipment currently commercially available, classified into rail mills, frame mills and carriage mills. For more information on the different mill types, refer to Pasicznik et al. (2006), (Pasicznik and Harvey, 2006), and/or the company websites included in the summary table of mill manufacturers.

Frame mills are probably the best known, original and most commonly available of chainsaw milling attachments. Often called 'alaskan' mills or 'slabbing' mills, they are also sometimes referred to by a manufacturer's name, especially in countries where that make is used exclusively, such as 'Granberg', 'Logosol' or 'Stihl' mills or frames. These are simple frames or guides that are fixed parallel to the chainsaw bar, and can be adjusted to be set at differing distances from the bar thus allowing for various cutting depths. They are used with the bar and frame horizontal for 'live', 'slab' or 'through and through' sawing, producing boards, slabs or beams of various dimensions. They are made of square tubular steel or aluminium, with or without rollers, and some makes have various sizes to accommodate different chainsaw bar lengths, and thus corresponding log diameters. When using a frame mill, slabbing rails, slabbing boards or similar attachments are essential for making the first cut.

Rail mills, with some variation, comprise of a small attachment that fixes onto the bar that rides along a 'rail' fixed onto the length of the log. They may have been developed by innovative freehand chainsaw millers to aid them in making straight vertical cuts through a log. Some attachments require the pre-drilling of the bar for the attachment to be bolted on to, others simply clamp on. Rails may be specially supplied metal units (strips, bars, angle iron, etc.) or pieces of wood, typically in common sizes such as 10 x 5 cm or 15 x 5 cm (4 x 2" or 6 x 2"), for nailing or screwing on to the log. Several rail mills have additional features such as an ability to set the chainsaw at angles other than 90 degree (vertical), cut mitres, control the depth of cut, or cut curved lines. As well as their advantage for producing custom timbers, many have been designed especially for the log cabin and timber frame housing market.

Carriage mills differ in that the chainsaw is fixed onto or into a carriage, which rides along a frame or set of rails. Most make horizontal cuts, though a few models make a vertical (or near-vertical) cut. These are all larger, heavier, more expensive, and require more setting up time than the simpler

alternatives already mentioned. However, they do then generally allow the user to cut more timber in a given time due to the reduced log set-up time, reduce muscular stress and strain and eliminate almost entirely the risk of accidents. Carriage systems cannot be carried by a single person, requiring a team or vehicle, and share many similarities with existing portable bandsaw and circular saw mills. In fact, several carriage mills can be upgraded to a bandsaw mill, i.e. the same frame can be used with a range of carriages and saw types. Saw types can be differentiated in a number of ways, including the maximum log length and diameter log that can be cut, the height the log has to be raised, and whether the cut is horizontal or vertical.

Potential for chainsaw milling

Chainsaw milling is peculiar amongst sawmilling techniques due to its high portability, low cost, and suitability for milling logs that might otherwise become firewood or left to rot. There are many types of tree or log that fit into this category, all of which are already milled by chainsaws at least somewhere in the world. The following is a miscellaneous list of potential and actual sources of sawn timber that have been identified as having some potential as an increased source of sawn timber for local markets with appropriate conversion techniques such as chainsaw milling.

- ❖ Farm trees
- ❖ Street and city trees
- ❖ Dryland trees
- ❖ Weedy trees
- ❖ River side and rail side trees
- ❖ Firewood and fodder trees
- ❖ Forest and woodland thinnings
- ❖ Trees of poor form
- ❖ Wind blown or fallen trees
- ❖ Diseased or damaged standing trees
- ❖ Washed up trees
- ❖ Small diameter logs
- ❖ Short logs
- ❖ Branches/prunings
- ❖ Oversized trunks
- ❖ Logging residues
- ❖ Sawmill waste
- ❖ Reclaimed timbers

farmers are, good at growing crops and raising livestock, but generally less knowledgeable and skilled in growing trees for quality sawn timber. Tree planting, weeding, pruning, etc. are all important but commonly overlooked. In some countries, farm trees are being harvested for timber but the volumes produced can be greatly increased with the proper management, and the returns to the farmer can be greatly increased if the farmer mills them, or has them milled, where

Table 1.1. The relative suitability of chainsaw milling techniques for different products and types of log.

	<i>Freehand milling</i>	<i>Rail milling</i>	<i>Frame milling</i>	<i>Carriage milling</i>
Type of timber				
Slabs	Yes	Yes	Yes	Yes
Edged timber	Yes	Yes	Yes	Yes
Quartersawn boards				Yes
Extra long lengths		Yes	Yes	
Type of log				
Small diameter logs			Yes	Yes
Short logs		Yes	Yes	Yes
Crooked logs			Yes	
Tapered logs	Yes	Yes	Yes	Yes
Oversized logs	Yes	Yes		
Side slabs			Yes	
Defective logs	Yes	Yes	Yes	Yes
Speciality cutting		Yes		
Various				
Portable by one man	Yes	Yes	Yes	
Approximate cost (US\$)	-	40-240	140-640	1000-3500

they are felled. Realising most of the value of the tree may then inspire farmers to plant more.

Dryland trees include trees mostly thought of only as sources of firewood or fodder but which often have very hard wood and yield valuable timber, including many acacia species for example. 'Recovery' in all these cases is not so much of an issue as all the wood would have become firewood anyway and even if only 10% of the wood could be converted to boards or beams, with a minimum 10-fold increase in value per volume from fuel wood to sawn timber, milling of at least the larger logs could make good economic sense if a high value market can be found to cover the labour, capital and running costs. arid woodlands and forests offer a valuable source of free or low-cost timber. In plantations, thinning is usually essential but often cost the forest owner money unless the sale of trees cut covers the cost of the operation, and if there is no ready market for pulp or poles they are sometimes just cut and left to rot, but should be considered as a possible source of sawn timber. In natural forests, chainsaw millers are already buying cheap concessions on logged over land, finding enough suitable logs left by the original fellers as 'logging residues', logs not the right length, tops, below the minimum diameter, branches, split or hollow logs, or even perfect logs that could not be extracted or were one too much for the last lorry, all providing a ready source of usable timber already on the ground with no felling required.

Chainsaw millers and the trees and logs they mill – a global perspective

The following description of some of the major current uses of chainsaws for milling timber includes freehand milling but concentrates on the use of chainsaw mills. Attempts are made to identify specific uses aiming to gain a better understanding into the situations where chainsaw milling may be viable and the reasons why. Their use by certain people in certain situations in general appears to be typical to chainsaw mill operation, and offers an insight into current and potential applications.

There are two main groups of chainsaw millers identified in the world today:

(1) forest-dependent people living in or near natural forests in mainly moist tropical and sub-tropical regions, largely milling freehand, either part-time or full time, and mainly but not exclusively, for local, national and regional markets.

(2) woodworkers, artisans, hobbyists, enthusiasts, farmers, etc., living in or far from forests in temperate and sub-arctic regions, involved in milling only part time with frames or other attachments, mainly but not exclusively for their own use.

There are exceptions to such a broad and simple classification, but this at least offers a basic framework for

looking at characteristics of who uses chainsaws for milling and what types of trees they mill. This is only rarely referenced for reasons given above and as such should be used only as a guide, but the information included has arisen from the global review process employed in this project (see Bibliography).

The development of chainsaw milling attachments over the past few decades, mainly in North America, Europe and Oceania, appears to have been driven mainly by a small and specialist group of people, often called 'hobbyists' or wood 'enthusiasts'. Characteristic common to such users include:

- ❖ they are not time- or capital-limited
- ❖ they often have access to logs as a free (or very low cost) resource
- ❖ they mill infrequently, and produce relatively low daily and annual volumes of timber
- ❖ they often mill with specific projects in mind
- ❖ they do not earn their living from timber sales, or at least not a significant part of it

The widespread availability and low cost of chainsaw milling attachments has since led to additional applications by a broader range of users in temperate and sub-arctic regions, including arboriculturists, forest workers and contractors, builders of timber frame housing, log cabins and other groups of professional craftsmen. These are people who are in regular contact with round wood, either as resources of little or no value, or who need to transform round wood directly into end products, particularly large dimension timbers that are not easily moved or in isolated locations.

A further distinct group of users in temperate and sub-tropical regions includes farmers and ranchers making use of timber resources on their own land, though peripheral to the main farm activities. Notable examples include ranchers in Australia and the USA, and increasingly, farmers in northern Europe, North America and Australasia.

In tropical high forests, in contrast, research has identified stakeholders in chainsaw milling from the standing tree to timber user, including:

- ❖ tree owners (government or private)
- ❖ concessionaires or other intermediate resource owners
- ❖ chainsaw owner-operators
- ❖ chainsaw owners who rent out equipment
- ❖ chainsaw sawyers who rent equipment
- ❖ labourers
- ❖ dealers of chainsaws, mills, spare parts, etc.
- ❖ timber dealers, downstream processors and manufacturers.

Tropical freehand users and temperate milling enthusiasts clearly have very different characteristics in terms of availability to capital, labour, land and experience, and any generalisations made between the two groups would be meaningless. Studies have been undertaken on the characteristics of, and the relative resources available to,

groups involved in almost exclusively freehand chainsaw milling in natural high forests in the humid tropics, e.g. Guyana (Clark, 2005b), Ghana (Odoom, 2005), Indonesia (Roda, 2005) and Vanuatu (Wyatt, 1996). No equivalent studies are reported on users of chainsaw milling attachments in temperate or developed country situations.

There are also very few studies on chainsaw milling from outside forests in the tropics, possibly due to the much lower volumes of timber being processed, the marginal economic importance and thus less interest. Where it occurs, it may be expected that, a similar array of stakeholders are involved, there are likely to be some notable contrasts. For example, in natural forests, the tree owner is likely to be the national government, and intermediate resource owners to be large national or international companies with multi-decade concessions over large areas of forest.

Outside forests, the tree owner is much more likely to be a private individual. In both cases, however, ownership may also be communal, as is common in natural forest on Pacific Islands, or in savannah and rainfed farmland in the Sahel. Chainsaw owner-operators will be much more prevalent in natural forests than outside forests, where the high volumes being cut allows this to become a full-time activity for some people which will quickly repay the investment in a chainsaw and possibly a mill.

Outside forests, the low volumes available mean that a chainsaw owner may be unable to find sufficient trees to make milling a full time activity, and will thus either rent out the chainsaw (earning income) or leave it idle (increasing saw life) for periods of each year. This is not the same as in the group listed above, 'chainsaw owners who rent equipment', which primarily includes business people in or near tropical forests who purchase and rent chainsaws as a viable economic venture, and may also be involved in downstream processing or timber sales.

There is likely to be a continued market for renting chainsaws and associated equipment both within and outside forests. Labourers will also always be required to assist in felling, milling and especially for carrying sawn timber to roadside. This is more likely to be full-time waged activity in natural forests, whereas outside forests it will be part-time, and labour requirements may be met by family members or others with low opportunity costs, such as out of season agricultural labour.

Very little data on actual volumes milled by chainsaw is available, and it is impossible to make any meaningful estimates on the amounts of timber that might be being milled by any of these professions or groups, with attachments or freehand or in any country or over any time period. In temperate and neighbouring regions, the types of trees most commonly being milled by chainsaw within forests include thinnings and wind blown trees in coniferous plantations. More common in such regions,

however, is the processing of trees outside forests, mainly single trees or those in rows or small woodlands, including on-farm trees, fruit trees, street trees, river or rail side trees and other lone or shelterbelt trees. The use of chainsaw milling for processing exotic weed tree species is evident, e.g. with *Cinnamomum camphora* in Australia (Brett et al., 1999).

Although there is a great range and diversity in the use of chainsaw milling and the trees being processed, some common characteristics do appear from temperate regions including, predominantly:

- ❖ low-value or no-value trees
- ❖ small diameter, short or crooked logs not suitable for other sawmills, and logging residues
- ❖ specialist high value timbers, often hardwoods
- ❖ trees from farm forestry or agroforestry
- ❖ street trees, rail or river side trees
- ❖ small diameter softwoods species and thinnings
- ❖ mature coniferous trees, on-farm, within forests and other single trees elsewhere
- ❖ logs in low volumes, in any situation

In the tropics, the situation is very different. Here, chainsaw milling is carried out largely within forests, and the tree species will be those that have an immediate and ready market, being commonly those already available in local, national and international trade. The characteristics of these trees are thus no different to those currently being harvested and processed by static or other portable sawmills, and are selected as in standard harvesting scenarios, based on species and size, and if legally procured, on an agreed volume per hectare per annum basis. In addition, there are reports of chainsaw milling being used in already logged over concessions, to process logs, often in considerable numbers and sizes, which for one reason or another were not extracted in the original harvest.

Outside forests in the tropics and sub-tropics, the use of chainsaw milling is still in its infancy, though rapidly gaining ground. In such situations, they are already being used to process on-farm and agroforestry trees, such shade trees including *Cordia alliodora* in Central America, *Grevillea robusta* and *Eucalyptus* species in East Africa, and numerous in West Africa, along with dryland species such as *Acacia nilotica* and *Prosopis juliflora*. While examples are few and generalisations unproven, it appears to be worth noting the characteristics of trees milled by chainsaw outside forests as a basis for discussion:

- ❖ trees within crops that would be damaged by harvesting and extraction machinery
- ❖ wide-spaced, isolated or inaccessible trees
- ❖ where there is immediate on-farm use for the timber
- ❖ higher value species with ready local markets
- ❖ short, crooked or non-standard sized logs of no interest to commercial sawmills
- ❖ lesser known species with no ready market

- ❖ street or boundary trees likely to contain nails or other metal
- ❖ No other sawmill types available or at long distances

Such a list is not likely to be exclusive, and many exceptions are probable, but it may give some indications as to the sorts of trees that are being milled by chainsaws in some areas, and thus where chainsaw milling appears more appropriate outside forests in the tropics.

Table 1.2. Productivity and recovery of chainsaw milling, freehand and with the aid of various milling attachments.

Country	Notes	Productivity		Recovery %	Source
		/hour	/8 hour day		
Freehand chainsaw					
Kenya	Grevillea			28-39%	Onchieku, 2001
Ghana	Various hardwoods			40%	Tropenbos, 2003
RD Congo	Grevillea and eucalyptus	0.10	0.8	37-55%	This report
Guyana	Locust and greenheart	0.15-0.23	1.2-1.8	19-22%	Clarke, 2005a
Phillipines	Coconut slabs	0.19	1.5	27%	Arancon, 1997
Indonesia	Various hardwoods		2.0	<5%	Roda, 2005
Guyana	Various hardwoods		4.2	10-25%	Grisley, 1998
Brazil	Various hardwoods	0.6	4.8	41-61%	D'Oliveira et al., 1998
Frame and rail mills					
Australia	Frame and rail mills			55%	Smorfitt et al., 2004
Kenya	Granberg Mark III - Prosopis	0.04	0.27*	25%	This report (*milling only, no felling)
USA	Granberg Mark III - Oak		0.6-1.2		Henderson and Krier, 1997
DR Congo	Stihl LSG 450 – Grevillea/eucalyptus		1.0	41-54%	This report
Mexico	Rail mill (unspecified)	0.13	1.0	40%	Richards et al., 2001
Australia	*Mean, 5 frame, rail and carriage mills	0.14	1.1	35%	Stewart and Hanson, 1997
Kenya	Granberg Mark III - Grevillea	0.2	1.45*	45-55%	This report (*milling only, no felling)
Carriage mills					
Canada	Procut 'make your own' - hardwoods		0.6-1.2		Company website
Canada	Procut 'make your own' - softwoods		1.2-2.4		Company website
New Zealand	FRI mill - Rimu		1.0	52%	James, 1985
UK	Lennartsfors SM 2196 - Oak	0.18	1.1	56%	Jones, 1998(as Jonsered 600+)
UK	Lennartsfors SM 2196 - Douglas fir	0.20-0.36	1.6-2.9	26-66%	Jones, 1998 (as Jonsered 600+)
Canada	Procut 'make your own'***		1.8-3.6		Company website
Sweden	Logosol M7 - softwood		2.3 -3.5	50-60%	Logosol M7 (quoting unspecified report)

*Including: Granberg Mark III, Westford Rail Mill, Beerwah Ripper Mk IV, MacQuarrie Chain Mill, Logosol.

** with a Stihl 090, 1 man helping, averaged over 7 years (www.procutportablesawmills.com/production.htm).

Output and recovery from chainsaw milling

The following tables present available data on the sawn timber outputs and recovery rates from chainsaw milling, to allow a basic comparison between selected data from other portable saw mills. Conversion rates used included (1) 8 hours in a working day, and (2) 424 board feet per cubic metre. Figures quoted usually refer to output per milling team, generally two to three people. Productivity is calculated as the quantity of sawn timber produced, and not the volume of logs milled. It is not always clear, however, whether recovery is from the whole log or just a squared cant thus this data should be treated with caution.

Freehand chainsaw milling gives high productivity, though is assumed to be more wasteful. Frame and rail milling give lower productivity though with improved recovery (and reduced risks of accidents, not assessed). Carriage milling gives the highest potential productivity and recovery, though with an associated higher capital cost required.

Single blade circular sawmills give similar rates of recovery and productivity as compared to the best chainsaw milling options, with of course a higher capital outlay. However, twin blade circular saws and bandsaws give much increased rates of production and recovery, and are clearly the best if adequate capital and log volumes are available. If not, it may be wise to consider one of the cheap, lower production options.

Table 1.3. Productivity and recovery of selected portable band saw and circular saw mills.

Country	Notes	Productivity /hour	Productivity /8 hour day	Recovery %	Source
Single blade circular saw					
Australia	Questionnaire	-		30-55%	Smorfitt et al., 2004
Papua New Guinea	'walkabout'	0.06-0.15	0.5-1.2	-	Salafsky et al., 1998
Australia	Trials	0.09-0.12	0.7-1.0	28-35%	Venn et al., 2004
Mexico		0.19	1.5	55%	Richards et al., 2001
UK	Lucas mill - spruce and oak	0.10-0.26	0.8-2.1	31-56%	Vickers, 1998
Tanzania	Av. 2.25 years of softwood thinnings	0.23-0.36	1.8-2.9	37-43%	Kowero et al., 1985
Malaysia	12-18 cm Diameter logs	0.36	2.9	44%	Seng and Hasim, 1983
Australia	25 mobile sawmillers	0.42	3.4	65%	Stewart and Hanson, 1997
Malaysia	18-33 cm diameter logs	0.50-0.61	4.0-4.9	60-63%	Seng and Hasim, 1983
Guyana	Trials	0.71	5.7	49%	Clarke, 2005
Tanzania	Av. 2 years of softwood thinnings	0.81-1.49	6.5-14.3	47-48%	Kowero et al., 1985
Twin blade circular saw					
UK	Blossom mill	0.86-1.13	6.9-9.0	27-33%	Vickers, 1999
Uganda	McQuarry - pine	0.31-3.12	2.5-25.0	25-50%	This report
New Zealand		1.52-3.82	12.2-30.1	-	Howard, 1981
Australia (Victoria?)	25 mobile sawmillers	2.37	19.0	65%	Stewart and Hanson, 1997
Bandsaw					
Australia	High throughput trials	0.14-0.16	1.1-1.3	43-48%	Stewart and Hanson, 1997
Mexico		0.22	1.8	60%	Richards et al., 2001
Australia	25 mobile sawmillers	0.27	2.2	67%	Stewart and Hanson, 1997
Guyana	Trials	1.33-1.62	10.6-13.0	58-70%	Clarke, 2005b
New Zealand		2.69	21.5	-	Howard, 1981

2 Building a decision-making framework

Criteria for choice

Chainsaw milling, with or without attachments, clearly already makes sense for tens or even hundreds of thousands of people in the world, in specific situations. Deciding why, how, when and where chainsaw milling makes sense over alternative milling technologies, as discussed in the previous chapter, is another matter. The different criteria for selecting which chainsaw, chainsaw milling attachment, chains and other accessories are covered in detailed in an associated publication, 'Turning Trees to Timber: A Chainsaw Milling Manual' (Pasicznik et al., 2006) and key issues will be repeated only in summary here.

However, from the global overview in the previous chapter it is clear under what conditions chainsaw milling with and without attachments is currently used in different regions of the world. Thus it is possible to extrapolate, and consider what potential exists for this technology, specifically outside forests in the tropics. The seven principle criteria identified are:

- ❖ The options
- ❖ Access to trees
- ❖ Productivity
- ❖ Available capital
- ❖ Availability of mills
- ❖ Labour considerations
- ❖ End products

This chapter covers some of the information needed in order to make such decisions. Basic information on the above options is readily available, and just requires recording. However, before investing often scarce financial resources, it is wise to have a detailed understanding of the economics of the business to be ventured into, and the following is intended as a generic outline of the economic information needed.

Economic information required

Information on the economics of chainsaw milling is generally sparse, partial, as well as being spatially and temporally specific. Literary comparison of different mobile sawmill technologies shows that there are many variables to assess, but that chainsaw mills have roughly half the productivity as compared to portable circular and band saw mills, at approximately 1.0-1.5m³/day, and sometimes produce 10% less timber per log. The assessment of the economics of chainsaw milling is complex, especially when specific to the site, species and log size milled, markets and operator skills.

Only selected micro level economics are presented, i.e. those likely to be common to forest margins, farms, drylands and other areas of low forest cover in the tropics and subtropics. A spreadsheet model accompanies this paper, allowing users to input most economic parameters, allowing assessment and comparison in many different situations. Conversion methods as well as productivity and efficiency vary with the type of sawmill, market demands and log size and quality, and therefore, this indicates only the potential of different sawmill types to undertake various conversion scenarios and likely efficiencies and outputs per hour.

The indicative context of the economics of chainsaw milling includes:

- (1) **Macro – country or district level**
 - ❖ Employment – direct, indirect
 - ❖ Taxes and revenues
 - ❖ Resource impacts
 - ❖ Infrastructure
 - ❖ Economic development – value addition, import substitution
 - ❖ Laws and regulation
 - ❖ Trade barriers, World Bank, NGOs, etc.
- (2) **Micro – family or entrepreneurial level**
 - ❖ Capital – fixed, working
 - ❖ Overheads – business, inventory
 - ❖ Variable costs – manufacturing, further processing, marketing
 - ❖ Other variables – recovery, productivity, infrastructure, species, availability
 - ❖ Revenue
 - ❖ Financial performance and sensitivity

To give a true picture at the enterprise level, the economics of chainsaw milling should be assessed over a period of time, such as a financial year, so removing or smoothing out individual operation variables such as log size, quality, season and location. Almost all studies, however, examine the economics only in a particular sawing operation.

Though methodologies have been developed to estimate costs in sawmilling industries (FAO, 1984), assumptions made to account for variability may be suitable for larger business, but are unlikely to be realistic for small enterprises such as mobile and particularly chainsaw milling in the tropics where access to finances, funds or equipment are likely to be within the family and seen as a normal way of carrying out the business.

Capital

Assessing the capital requirements for a chainsaw, milling attachment and ancillary equipment is relatively

straightforward, as manufacturers or others in the supply chain can be asked to give quotes for delivery to a specific location. Allowing 10% of processing and ancillary equipment value estimates is a necessary 'hedge' fund to allow, for instance, for a major breakdown of equipment. However, within a family type enterprise such a hedge fund may be held as family savings or 'emergency goods' for trading. Therefore, if a strict 'accountant' view is rejected, this could be ignored. Pre-operating expenses could similarly be ignored as the opportunity cost of storage facilities is likely to be negligible and safety equipment designated as ancillary equipment.

The capital required for transporting logs is very variable, e.g. whether carried out by hand, animal, boat or lorry. One way to account for this in a single operation rather than over a financial year is to include a charge in the variable costs equivalent to local hire for transporting people and equipment to and from the milling site, or an estimate based on local conditions.

Working capital in much of the tropics may need to be quadrupled to allow for difficulties and time taken to order and receive spare parts. Further processing equipment is an unusual occurrence for small operations and so can be ignored in a general assessment of producing rough green timber.

Overheads

Insurance in areas of low forest cover in the tropics is unlikely and so is ignored. Concession payments will depend on the situation and ownership patterns.. Loan repayments will be dependant on credit facilities within the local area and the interest rates charged. Interest rates and terms can be a major factor in the economics of chainsaw milling especially in times of high inflation.

Depreciation on capital items such as chainsaws will be fairly high, at up to 50% per year if in full time use given a life expectancy of between 1500 hours (Mitra, 1979) and 1800 hours (Arancon, 1997), as against other items such as milling frames where 15% or less per annum maybe more applicable. Casual staff or family members are typically used in chainsaw milling operations rather than permanent staff. The Meru economic model presented in this paper, uses conservative primary data from powersaw owner operators, suggesting a total lifespan of 5400 hours (150 days per year at 6 hours per day for six years)

Administration costs are always difficult to assess as they could vary from insubstantial with a farmer selling timber roadside, to very large with negotiations for log access, documentation of management procedures and cooperative or family enterprises running the business. The estimate of 15% of manufacturing costs for administration and overheads suggested by FAO (1984) is likely to be unrealistic because manufacturing costs per metre of sawn timber is higher in chainsaw milling, and in large static sawmills log

transportation is a large feature of the economics. It could be postulated that 15% of the opportunity cost of one family member be a more realistic estimate of administration costs, with overheads being assessed as in the previous elements.

Inventory costs could be substantial where trees are felled or processed some months before they are transported to the point of sale, or timber is stockpiled before transportation. This would be evident in a particular milling enterprise situation, otherwise inventories would have little effect on the economics (Stewart and Henson, 1997). Where further processing such as air or kiln drying is undertaken, considerable capital is employed in drying stocks, as much as four months sawing output. As green timber is generally only sold in Kenya, this cost is nor accounted for in the modelled economic assessment..

Variable costs

Log finding could be a substantial cost, calculated to be 3% of total costs for static mills in moist Brazilian forest (Verissimo et al., 1995). In dryland Australia, 10% of the total time taken to select, fell, prepare and mill acacia trees was for tree selection (Venn et al., 2004). Local knowledge or firewood collectors are likely to be used in low forest cover situations rather than direct employment of log scouts, but this could still represent a substantial cost for which there is no current evidence, and log finding may be a hidden cost in some assessments of the economics of mobile milling. The economic model for Meru Kenya, using data collected assumes 2.5 – 3.5 hours of finding trees, negotiating sale, gaining felling and transport licences per full day of milling.

Log payments and timing will depend on the species and situation in the field and ownership patterns therein. In Meru district, cash was paid on standing tree purchase. Again, milling site preparation and making extraction tracks varies according to specific sites and situations, but in areas of low forest cover, neither is assumed to be substantial.

Felling, delimiting, and log preparation is a major cost element in all log pricing and sawmill economic assessments. Substantial cost increases per cubic metre of sawlog can be added for small logs and sometimes very large and buttressed logs. Venn et al (2004) calculated that with acacia trees in drylands, 25-29% of the total time was taken in felling and delimiting. Positioning logs and setting up to saw can be time consuming, calculated as up to 3-4 hours per tree for freehand milling, depending on the size of the tree and the terrain (Tropenbos, 2003). In areas of low forest cover and with smaller diameter trees this will be less, though 1-1.5 hours has been estimated for large on-farm trees in this report. The Meru economic model presented in this paper, uses field observations to estimate 1.5 hours per day of felling, delimiting and cutting to length in every day milling.

Fuel and oil used is eight litres and three litres, respectively, per full working day (Arancon, 1997; Salafsky et al., 1998), confirmed in studies in this report, but Richards et al. (2001)

cite the use of 20 litres of fuel per cubic metre, a considerable difference. Spares and saw maintenance are likely to be limited to chain sharpening and bar profiling, with an estimate of 4 new files and four new chains per month (Arancon, 1997) appearing reasonable. The Meru economic model presented in this paper, uses field observations of 8.5 litres of fuel and 0.9 litres of two stroke oil (local mix ratio) for felling and milling.

Transport is once again very variable. One way to account for this within the context of a single operation, rather than over a financial year, is to include a charge in the variable costs equivalent to the local hire costs to transport people (as used in the Meru model) and equipment to the milling site. Otherwise, an estimate based on local conditions would be required. Casual labour rates will be localised. The time taken to mill timber will depend on travel, log preparation, positioning and milling time. In some areas, additional labour will be used even if it is not necessary such as for patronage or for access to logs.

Site amelioration, logging repair and other forest operations can take considerable time, dependant on local conditions and requirements. Some mobile sawmill operators in developed countries operate by principally undertaking forestry operations such as thinning and clearing weeds with additional income sources derived from the conversion of suitable logs into milled timber. This could be a model for forest margins and areas of low forest cover in the tropics where the principle operation is fuelwood collection, with timber milling secondary.

A contingency allowance of 5% of manufacturing costs is suggested by FAO (1984). This is to allow for breakdowns in equipment and the necessary spare parts inventory. Again it could be argued that family assets are the likely source of contingency allowances.

Further processing will often be necessary to turn green sawn slabs into marketable timber, even if this is just resawing them into 10 x 5 cm building timbers. Scherr et al. (2003) details an indicative cost and value chain of export timbers initially processed by mobile circular 'walkabout' mills in Papua New Guinea, demonstrating some of the further processing costs of kiln drying. Arancon (1997) assess the further processing costs of turning coconut slabs into saleable timber via circular saw dimensioning and preservative treatment. Many sources concentrate on the initial breakdown costs and tend to ignore further processing costs as well as marketing costs, but this may indicate there is no further value to be gained from secondary processing of timber or their work is focussed on initial breakdown.

Marketing costs are often ignored, but can be substantial, and Stewart and Hanson (1997) found marketing as the most important factor in the sensitivity of profits. It is not surprisingly neglected due to the large variations in costs, time and revenue, often highly localised and dependent on the skills of the chainsaw milling business. 'Middlemen' are

seen to play an important role, with chainsaw millers being 'price-takers', i.e. having no ability to influence prices (Stone, 1996). Being part of a marketing cooperative is often cited as a method of marketing products from small volume producers to a wider market. However, these are not always successful (e.g. Richards, 1993). The Meru economic model presented in this paper follows the local pattern of marketing, in the setting up a small timber sale yard and account is made of these costs.

Non-financial variables, revenues and results

Non-financial variables are critical to the economic performance of milling and need to be detailed, to put any economic assessment into context. Two well documented elements are the conversion and recovery rates (see Table 1.3). However, the variables of log form, size, defects, products produced and whether other elements of saw or log set-up have been included are often absent, making comparisons between different sawmill types and manufacturers unreliable. Infrastructure influences on the economics of chainsaw milling are often critical. This may mean that mobile millers are able to access timber that fixed sawmills cannot, due to the absence of tracks and roads, but this can also add significantly to costs as would be taken into account by transportation costs. Markets and competing products also have an influence, but are difficult to include in a financial analysis.

The species milled and log availability greatly influences the economics of milling, but is surprisingly not always detailed in economic analyses. Local and export markets often demand particular species, ignoring or offering a markedly lower price for suitable but lesser known ones. However, adding value, such as making specific building timbers or furniture, can overcome this. The availability or access to logs may require considerable negotiation and time, as such can be included in the administration costs, as has been mentioned previously. Revenue is determined by the markets supplied, but many sources of information do not indicate the end product of sawmilling, and if it is a local market value it may be based on estimates or indicate further processed pricing. The Meru economic model that accompanies this paper, provides for species, size and form/quality variation.

Results can be presented in a number of ways. For existing and potential chainsaw millers, their interest will be focused on profits, cost of machinery and of borrowing, partly because it may be difficult to comprehend what effects the other measures have. Due to the weaknesses and specificities of economic assessments, it is difficult to have faith in the economic results produced. The exception is the cost of the saw operation related to conversion and recovery rates, as this is what is measured in most assessments.

Non-economic considerations

It is clear that a wider perspectives, rather than just an 'accountants' view of the economics of chainsaw milling, is required for analysis in any assessment. This should take into account competing land uses, cultural and tribal differences and allow for possible participatory forest or other types of equitable land management. Such a wider perspective is the methodology employed with Economic Stakeholder Analysis (ESA) (Richards et al., 2003), and which has been followed for developing the framework in the principal case study in Kenya.

Other important direct livelihood issues relate to social issues, particularly the role of organised crime and corruption, indigenous groups' relative access to resources, and the importance of health and safety aspects, particularly the risk of accidents and their effects on livelihoods.

Equally important are environmental considerations, and the need to assess the effects of different practices on natural resource quantity and quality, sustainability, durability, over-exploitation, land degradation, etc. These relate for example to issues concerning reduced impact logging (RIL), pollution, erosion control, and potential damage to biodiversity, other trees and/or sensitive environments.

Introduction to a decision-making framework

The economic appraisal of chainsaw milling has utilised as a basis the methodology recommended by Richards et al. (2003). The 'economic stakeholder analysis (ESA) is primarily intended for forest management or forest use options in developing countries, where complex drivers and constraints exist. The six main stages of ESA are:

- (1) Identification and characterisation of stakeholders.
- (2) Understanding the decision-making context and the role of economics.
- (3) Identification and physical quantification of costs and benefits.
- (4) Valuation of costs and benefits.
- (5) Economic comparison of the decision-making alternatives.
- (6) Participatory analysis and monitoring.

The ESA proved useful in this study of the introduction of chainsaw milling attachments into Kenya and elsewhere in East Africa, as compared to widespread freehand chainsaw milling. It accounted for their economic, environmental and social appropriateness and assessed the potential uptake of this 'new' technology. However, not all of the methodology suggested by Richards et al. (2003) was followed for the following reasons.

- ❖ This project does not involve participatory forest management (PFM) because the central focus of the study is the impact of the introduction of a new technology, not a forest management project as the book is primarily intended for.
- ❖ This project uses Multi-Criteria Analysis (MCA) in a partial manner, as considerable time is required to undertake it. MCA is considered a prime method for the appraisal of options for government officials on policy and other decisions including those with environmental implications. It would have formed an exemplary way to provide a Decision Support Tool and is suggested for detailed follow-on work.
- ❖ Another major piece of work suggested by Richards et al. (2003) is Section 7 of the data collection framework, 'Implementation, monitoring and improvement of data collection frameworks and decision support systems' in other words a feedback system to improve the assessment has also not been completed though would prove valuable in future studies.

Not present in the procedures indicated by Richards et al. (2003) but included here as an additional initial section primarily examines the policy and regulatory context, called 'Stage 0'. It has been added because of the influence the regulatory environment and its implementation has in most countries upon virtually all issues related to forests and timber.

Therefore, the methodology of Richards et al. (2003) has been used as a modified structure through which an assessment of the potential impact of introducing chainsaw milling attachments is made. Additional sections have been added and others mentioned but not studied due to lack of time and relevance to the purpose of the study. Due to this approach of detailing the various influences on stakeholders, the study is specific to Meru. To assist in providing a wider East African context, guidance notes at the beginning of sections have been included. Despite this area specific detail, many of the issues are East African wide and directly applicable elsewhere.

3 Case study, Meru, Kenya

Overview of timber production around Meru

Meru Central, Kenya is classified as a high potential zone, with tea, coffee, cotton, cereals, dairy and horticulture farming common. Mean annual rainfall is 2600 mm in the upper highlands, and 500 mm in the lower altitude dry areas, with a mean altitude of around 2000 m. Before 1980, timber came from the natural forests on the slopes of Mt Kenya, cut by pitsaws and increasingly by static circular sawmills which became established in numbers, and later with the introduction of mobile, tractor powered circular saw 'bench saws'. Chainsaws also began appearing from the early 1980s for felling and to a limited extent for milling. This situation continued with little change until the 1999 Forestry Bill outlawed harvesting from natural forests.

This changed everything. Many of the large static sawmills were forced to close down due to a lack of trees. It also became immediately apparent that if trees were not to come from the forest, they could come from the farm, as the district was densely populated with large size trees, mainly grevillea (*Grevillea robusta*) but also cypress (*Cupressus lusitanica*) and eucalyptus (*Eucalyptus saligna*). Indigenous timber tree species also common on farm here include: *Vitex keniensis* (Meru oak) and *Cordia africana*, many of which had been planted before Kenyan independence.

A substantial amount of grevillea was also planted during extension related projects in the 1980s, e.g. the extensive EMI project which planted all the roadside grevillea in the region. Grevillea and eucalypts were also promoted for shade in the coffee and tea zone respectively. Many of the indigenous species are also found to be remnants of natural forest species, though had never before been considered as a source of timber due to the readily available timber trees from the natural forests.

Whereas some static sawmills continued to exist, bringing in on farm trees as round wood for milling, the exploitation of on farm trees appears to have favoured portable milling, as many mobile circular saws sprang up, exclusively of the tractor towed and powered 'bench saw' type mills.

Increased harvesting of farm trees occurred in the years immediately following the 1999 presidential moratorium of forest logging. Currently, over harvesting is common and is referred as 'timber mining' by some, to make up for the shortfall in supply. Many of the larger sized and easily accessible trees have already been felled and milled, leaving millers, dealers and brokers to travel further (>20 kms), also as a result of price increases and price awareness in more accessible locations.

Larger trees are now more likely to be found in areas distant to Meru, valley bottoms and other inaccessible areas, and the chainsaw miller found himself a role. Such trees are felled and milled by chainsaw either into boards for immediate sale, or into slabs for carrying out and re-sawing by bench saw, either at the nearest point a tractor can reach, or at a yard or other collection point where the slabs remain until a buyer comes and specifies the dimensions required.

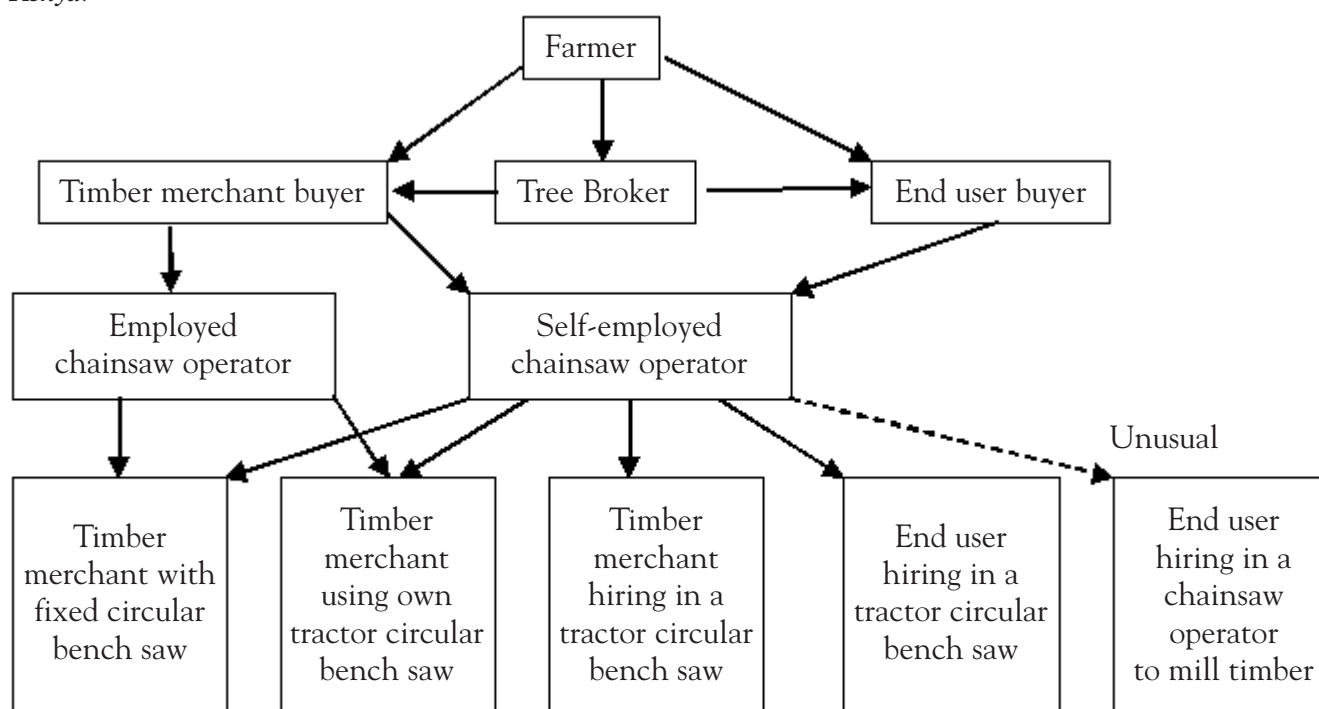
Chainsaw milled timber is of generally poor quality around Meru, with those using such operators having to insist on much larger dimensions to be cut than those required to allow for considerable planing that is required to obtain a consistent thickness and acceptable finish. Poor quality of chainsaw milled timber is variously explained as being due to chainsaw operators being unskilled, part time, lacking the required experience, or from drinking alcohol while milling to overcome fatigue.

From the point of view of the producer, i.e. the farmers themselves, 'the farmer never wins'. Inadequate market information for agricultural crops and declining prices for commodity crops, especially coffee, have forced many farmers into situations when they are in dire need of money, such as for school fees, hospital fees, weddings, funerals, etc. Trees are a ready investment providing a source of instant income.

However, buyers, whether individual end users, timber dealers or brokers, are aware of their precarious financial situation, their lack of tree valuation techniques and market access. In these instances, buyers exploit this to their financial advantage by obtaining a price for standing trees that is below the prevailing market value. The prevalence of timber brokers, i.e. those that buy standing trees and sell them on still standing, is an example of this as well as the need for the aggregation of single trees from a number of farms in a small area to allow economic milling. The single most commonly heard view from farmers regarding their trees concerns valuation, and that they feel that they rarely, if ever, receive a reasonable price. This is a situation forced upon them because they lack financial capital and skills in assessing the value of their trees in terms of volume, quality and adequate market information. Indeed there seemed to be no one who bought trees on a volume measurement, only girth. This underestimates the value of large trees as volume increases at twice the rate of diameter.

Little or no value adding is undertaken for trees obtained from farms. Farmers rarely have the timber milled themselves for sale. Negotiations over price will include whether the buyer takes the firewood as well as the logs, and prices can be extremely variable depending on the

Figure 3.1. Market routes for trees to timber in Meru, Kenya.



immediacy of cash need, tree quality and species (indigenous species costs more) valuation knowledge of the farmer, accessibility, and what might be termed 'personal ownership', meaning whether they have grown and tended it themselves or see it as a 'free gift' planted by previous owners or generations. Timber prices are relatively high in Kenya at present due to the shortage in supply.

There are several types of buyer. The first is the private individual, perhaps a neighbour, extended family member or other person who requires timber for a certain project such as building a house, who then hires a chainsaw operator alone or a chainsaw and bench saw in combination, to mill the trees into the desired dimensions, which is relatively common. Perhaps also in this category are also some other larger corporate users e.g tea factories, schools, hospitals which fell largely on farm mainly for firewood. Cases of timber quality trees being felled for firewood are common. Intermediaries may be used to source the wood.

The second is a timber 'dealer' (which means that they also own some form of sawmill), who buys the standing tree and either mills the tree on site with their own bench saw, hires one in, or takes the logs away to a static sawmill, selling the sawn timber on to end users or other dealers.

The third is a timber 'broker', who buys and sells the tree standing, making profit without any physical effort, and often offers the lowest prices to farmers, but they may also be called 'tree finders' who are hired by either of the first two groups to locate trees and negotiate the cheapest price.

Increasing the financial benefits to farmers from the production and sale of farm trees may follow one or more of a number of routes. The way most often stated is to avail to farmers market information on the current value of standing trees, per species, volume and quality, so allowing them to obtain a better price, even in the face of their immediate economic needs. Techniques on mensuration and valuation would also help bargain for better prices.

However, an alternative means would be whereby farmers could organise primary processing themselves, either by hiring contract sawmillers to process the trees, or by hiring the equipment and milling themselves, then selling the sawn timber on, either to timber yards or directly to end users. If processing themselves, farmers often state the lack of resources as one reason for not doing so. This may mean that chainsaw milling could appear a more appropriate method due to its low capital cost and simplicity of operation for farmers. Contractual arrangements could also work for corporate buyers.

Constructing a decision-making framework

(0) Policy and legislative framework

Guidance notes: Legislation, regulations and policy gives insight into understanding past, present and future actions. For example, if the regulations concerning the felling and conversion of farm trees into sawn timber are difficult or expensive to meet, then farmers are unlikely to plant and tend trees that produce sawn timber and/or mill illegally. The same result could also occur if no regulations or enforcement are present, allowing exploitation of forests and so depressed timber prices.

Policy and legislation are analysed but not in detail for two main reasons.

- ❖ The risk of legislation banning the use of chainsaws or attachments is assessed to be low from discussions with various Kenyan government departments, though there is a ban in Uganda but which is seen as ineffective.
- ❖ The laws are due to change with the implementation of the Kenyan Forests Act 2005, but the operational details and their effect on the current practices are yet to be communicated.

Policy framework for timber conversion and forestry

Guidance notes: Summarise national forest policy, national environmental protection policies, regional and local policies on their intended effect on the use of trees for chainsaw milling, timber sales, markets and on those undertaking or potentially undertaking chainsaw milling.

It is understood that currently there are no policies on the use or sale of chainsaws, milling attachments or other small sawmills. There are a number relating to the harvesting and movement of timber products, discussed later. After several years of inactivity, the Forest Bill was provisionally passed at the end of 2005 (Government of Kenya, 2005). It is as yet to be implemented and as such previous laws were still adhered to in January 2006, where known. The current situation is presented, and Ludeki et al. (2006) present a clear assessment of the Act.

The Forests Act 2005 provides for the following:

- ❖ Establishment of a forest authority known as the Kenya Forest Service, to formulate policies and regulations for all forests, manage and conserve indigenous forests and manage provisional forests in consultation with the owners.
- ❖ Apply stringent measures for conversion of indigenous forests to other uses by application of Environmental Impact Assessments (EIA), consultation with local forest conservation committees and approval of the change of land use by parliament.
- ❖ Recognition of local community members as major

stakeholders in the management of indigenous forests. The Bill provides for the formation of associations to participate in forest management, conservation and forestry development with joint management agreements, as well as representation of the communities in local Forest Conservation Committees.

- ❖ Sustainable management of indigenous forests for water, soil and biodiversity conservation, cultural use and heritage values, recreation and tourism, carbon sequestration and sustainable production of wood and non-wood products.
- ❖ Enhanced conservation of biodiversity and water catchment protection, through an aggressive afforestation and natural resource programme to replace exotic trees with indigenous species.
- ❖ Management of industrial forest plantations on a sustainable basis, for production of wood and other forest products and services. Management of industrial plantations has been identified as one of the functions that could be leased to the private sector on a pilot basis.
- ❖ Promotion of commercial tree growing by the private sector, farmers and communities through provision of incentives for forestry development. Under this arrangement, it is expected that more land will be set aside for forest development leading to increased forest cover.

The other main legislation affecting forestry is the Environmental Management and Co-ordination Act (EMCA), 1999 (Government of Kenya, 2000). This is the umbrella legislation governing management of natural resources in the country. An independent National Environment Management Authority (NEMA) has been established to implement the provisions of the Act. The Act specifically addresses the issues relating to protection of forests, reforestation and afforestation, energy conservation and planting of trees or woodlots and conservation of biological diversity. The Act provides for public involvement in any major development decisions, which have an environmental bearing. Land use change, which includes conversion of forestland to other uses, is requires an Environmental Impact Assessment (EIA) by an independent body. The Act also makes provisions for addressing environmental offences including the establishment of a tribunal to deal with such offences and the due process.

The Timber Act (Cap. 386 of 1972) provides for control of the sale and export of timber by means of grading, inspection and marking, and requires permits for timber transit which are issued by the Forest Department. The export of unprocessed indigenous timber is banned at present by Presidential Decree. Other laws which effect forestry issues are the:

- ❖ Wildlife (Conservation and Management) Act (Cap 376) 1977, which the Kenya Wildlife Service (KWS) regulates amongst other aspects of game hunting on public and private land. In Meru the KWS have assisted in erecting an electrified fence along some of the gazetted forest

boundaries to try and stop elephants damaging farmers' crops.

- ❖ The Trust Lands Act (Cap 288) 1962, covers all land which is neither private nor governmental, relating to local authority (council) land held in trust for the benefit of residents. In 2003, 78% of land in Kenya was classified as Trust Land.
- ❖ The Water Act 2002 through the Catchment Area Advisory Committees advising the National Water Management Authorities gives powers over issues regarding water catchments including prohibiting activities, for which compensation should be paid.
- ❖ The Antiquities and Monuments Act, Cap. 215 of 1984, where any land of cultural significance may be protected, thus gazetting national monuments, then falling under the management of the National Museums of Kenya. Several of these include forests of cultural and biodiversity significance, such as the Njuri Ncheke in Meru.

Legislation, codes of practice and other rules on tree felling, conversion sales and marketing of timber.

Guidance notes: Repeat the previous section where different but for enacted laws and their enforcement. Compare with the actual evidence of how these affect the use of trees for chainsaw milling, timber sales, markets and those undertaking or potentially undertaking chainsaw milling.

This information resulted from primary data gathered from local and national government departments, NGO's, sawmillers, farmers and chainsaw operators in January 2006. Farmers are not allowed to fell any native tree species on their land unless they show good reason to the District Environmental Committee (DEC) of NEMA (National Environment Management Authority). Farmers may cut fewer than ten exotic tree species on their land for domestic use without a permit as long as the following criteria are met: trees are not within 10 m of a water source or wetland; are not on a steep slope; are not immature; and harvesting them does not clear of all the trees on the farm.

If farmers want to sell less than ten trees then they must apply for a free permit from the DEC, which meets twice a month. Principle players include the District Forest Officer (DFO) and DEC Co-ordinator, who will send an agricultural or forestry extension officer out to make an inspection. No permits have ever been refused. The DEC has no legal basis to stop the felling of trees on private land. If more than ten trees are to be felled then the Committee or some of its members visit the proposed felling site to assess.

Anyone who wants to transport trees must apply for a Forest Produce Movement Permit. Usually free, it was unclear under what circumstances a fee of Ksh500 was noted as being paid by one sawmiller. The Forest Department sometimes issues movement permits along with felling permits. The movement permit is understood to last for three days, in daylight hours only and applies to charcoal, firewood and sawn timber.

There are many reports, both primary and secondary, of the felling of trees without permits. Some officials estimate up to 30% of farm sourced timber maybe felled without a permit. The Forest Department indicated that up to 100 tonnes per month of timber from gazetted forests is illegally harvested, with about 60% caught by forest guards or other enforcement agencies. Currently all harvesting of native trees in gazetted forests is banned.

Since 1999, all gazetted forests have been closed to timber harvesting, including the 120,000 ha of plantations, excepting supplies to large scale timber industries. State plantations have, however, continued to supply the Kenyan Tea Development Agency Limited (KTDA Ltd) with 40-60,000 m³/yr of firewood for tea drying, the Pan African Paper Mill with 300,000-450,000 m³/yr, plywood manufactures Riply and Timsales with 1,000,000 m³/yr and the electricity industry with approximately 100,000 transmission poles per year (Mr. I. Kuria, Economics and Marketing, Kenyan Forest Department, pers. comm.).

Legislation, codes of practice and other rules

Guidance notes: Repeat as required to allow the wider context to be understood and highlight strengths and/or weaknesses. In Kenya, information would include that from District Environmental Committees, Sub-Location Development Committees, Forest Department- District Forest Offices, Kenya Wildlife Service, etc.

The National Environment Management Authority (NEMA), Provincial Environmental Committees and District Environmental Committees (DEC) have little real power of enforcement. This is seen as a result of under funding leading to insufficient staff covering large districts. As far as is known, NEMA has not appointed any Environmental Inspectors as envisaged by the Act. The EMCA gives no legal basis for preventing the cutting of trees, however the Chief Conservator of Forests in a Circular in 2000-01 gave powers to the DEC's to regulate felling.

Concerning government and public organizations, forest resources are currently managed by the Forest Department of the Ministry of Environment and Natural Resources. The department is responsible for the conservation and management of all government forests besides providing technical support to other stakeholders, especially farmers, local communities and the private sector. The main areas of management are plantations, natural forests, farm forestry, dryland forestry and planning. The Department is headed by the Chief Conservator of Forests and is divided into 3 divisions, headed by Deputy Chief Conservators of Forests, namely Forest Management and Conservation, Planning and Development and Forest Extension. The divisions are further subdivided into 6 branches that are headed by Assistant Chief Conservators of Forests. Some main branches are Reforestation and Partnerships, Natural Forests Conservation, Farm Forestry and Extension, Dryland forestry, Forest Health and Protection, Management

Services, Planning and Finance and Administration. Each of these branches is further sub-divided into sections.

Concerning decentralisation, district-level forestry planning initiated by the 1994 Master Plan has given power of local planning to assist cooperation between government agencies, NGOs and communities. Currently, operations are decentralized to the 8 provincial and 71 district forest offices. Forest stations are the operational units in protected forest areas, while divisions are responsible for delivery of forestry extension services. Issues related to granting of licenses and gazetting of forest areas are examined at District and Provincial levels. For an overview see Mwichabe (undated).

Institutional barriers to certain groups for access to timber resources, infrastructure or markets

Guidance notes: These should also be identified in stakeholder analysis, and may range from outright documented bans to non-legal but effective barriers on certain groups. Not assessed.

No institutional barriers to the use of chainsaws other than poverty and so limited access to money, were observed. However, given the limited knowledge and communication in implementation of rules, regulations and laws, it is clear that there are additional barriers, including misunderstandings on governance of conversion, sale and transportation of timber and charcoal. Many officials were unclear and vague, sawmillers a little more sure, but farmers usually did not know of the process at all.

Further, some extension workers did not indicate to farmers likely tree prices, even if they knew, for reasons which were not clear nor were they comfortable to expand on. Knowledge of ways to measure tree volume seemed completely absent, though knowledge of sawn timber prices by the running foot was widely known. Therefore, bargaining for tree purchase between the farmer is subjective, not based on volume in the 'hands' of the buyer, and so very one sided.

The new Forest Act 2005 will create a number of barriers in accessing plantation timber likely to become available for

Causes of Forest Loss as seen by the Kenya Forests Working Group

<http://www.kenyaforests.org/forestsoverview.html>

Market Distortions. Currently forest products from gazetted forests are cheaper than those found on privately owned land. Illegally obtained products are almost free save for labour. This has numerous negative effects, including loss of revenue for the Government and loss of forest land for the nation.

Land Use Policy. Kenya urgently needs a clear land use policy. A Land Use Policy is now being developed to address this problem.

Non Residential Cultivation (NRC). The abuse of the NRC ("Shamba system") has contributed to encroachment of indigenous forests and accumulation of planting backlogs. The government has currently discontinued NRC, which needs to be implemented as intended to protect tree seedlings after planting.

Wood fuel (charcoal and fuelwood). Illegal cutting of indigenous trees for charcoal and fuelwood has threatened some forests. Alternative approaches are needed to address charcoal and energy requirements.

Nyayo Tea Zones. One of the purposes of establishing the tea zones was stated to be the provision of a physical buffer zone between agricultural land and forests designated for protection. Some of the areas cleared were unsuitable for tea and some remained unplanted. Reforesting these open spaces is one way of increasing forest cover in the country.

Limited Security of Tenure. When local communities have no sense of ownership, they are likely to overexploit forest resources and to be unwilling to engage in tree planting and forest conservation. The proposed new Act has provision for community participation in forest management and conservation.

Forests on Trust Lands. Often local authorities lack expertise to manage the forests under their jurisdiction. Technical advice and political will are needed to manage Trust Land forests for the present and future.

Changes in Land Use. Allocation of forest land for purposes other than forests has contributed to forest loss. Examples include official and de facto excisions for settlement. Other changes include cultivation of bhang (marijuana), mining, quarrying and uncontrolled grazing of livestock.

Logging. Logging of trees such as camphor for timber, muhugu and mpingo for wood carving and *Prunus africana* for medicinal bark threatens existence of these trees.

Resource limitations. There is insufficient allocation of resources within the Forest Department to effectively enforce regulations.

sustainable exploitation from gazetted forests. The barriers are that to bid for concessions or licences, management and Environmental Impact Plans or statements (EIS) are required. This will be outside the ability of small sawmillers in the district. The act also envisages the formation through community participation of 'community forest associations' who, amongst other aspects, may have the right to harvest timber. It would therefore suggest the only way local sawmillers may gain access to timber from the local gazetted forests is through joining or forming a 'community forest association' such that the pre-requisite plans and assessments can be economically produced.

(1) Stakeholder assessment

Guidance notes: Here the wider effect of future or current practices of using chainsaw mills is assessed on the various stakeholders. Stakeholder drivers and reactions, winners and losers, need to be understood. This can be assessed using Participatory Rural Appraisal (PRA) methods, or Participatory Forest Management (PFM) techniques where commonly owned resources are to be used such as Community, State or National Forests. Not assessed.

This section is not assessed in this study as the focus is on the introduction of 'new' technology not forest management. However, comments are made where there is relevance. The FAO have published a useful 'community toolbox' for this (Davis, 1990).

Identify, prioritise and classify main stakeholders by area including land and tree ownership patterns

Guidance notes: Identify and classify stakeholders into groups. Common stakeholder groups likely for chainsaw milling are by gender, family income levels, farmers (including transhumance pastoralists, land owners and shamba groups), ethnic groups, local and non-local forest users, institutions and government, timber merchants and sellers. Be aware of the large number of community and self-help groups which may or may not cut across other stakeholder groups. Not assessed.

Main stakeholders include: sawmillers, timber merchants, chainsaw operators and owners, farmers (small, medium large), absentee landlords, Kenya Tea Development Agency (timber for drying), Tobacco Companies (timber for drying), Sub-Location Development Committees, Forest Department, District Forest Offices, the National Environmental Management Authority and the District Environmental Committee.

Secondary stakeholders include: the landless, squatters, shamba farmers, rental (tenant or share cropping) farmers, men and women's self-help groups (registered through social services in Meru), cash crop groups (agglomeration of production to enable contract arrangements), community interest groups, church groups, chiefs, headmen, county

council, Kenya coffee unions, agricultural extension and cooperatives agents, district commissioners office, county council (trust lands), Kenya Wildlife Service (especially regarding migrating elephants and electric fences at the edge of Meru's gazetted Forests), the Green Belt Movement, Njuri Ncheke (tribal laws, customs and dispute resolution). With the drought (2005-06), livestock herders from the arid north and west were evident in the district to save their animals and themselves from starvation.

Scope objectives and livelihood alternatives for stakeholders and sub-groups

Guidance notes: Gain understanding of the relative importance of chainsaw milling for the identified groups, remembering seasonal effects. Participatory Rural Appraisal (PRA) methods can rank and score livelihoods, income and benefits. Not assessed

Given the alternatives of mobile circular bench saws and static bench saws in Meru, chainsaw milling will be of interest to stakeholders due to the economic returns it can generate. Three groups who will be most affected are farmers, landless semi-skilled/ unskilled people (including unemployed young men) as well as existing sawmillers.

- Farmers will benefit in two ways; from more competition for trees and so potentially better prices as well as being able to sell previously inaccessible trees.

- For landless semi-skilled, unskilled or unemployed young men, chainsaws are already seen as a future source of income. Currently, the path they tend to follow is first as assistants to chainsaw operators (often unpaid) to learn the trade, then hired by a chainsaw owner to undertake work for sawmillers and tree buyers, to save or borrow money from family to purchase their own chainsaw so becoming an owner-operator or owner hiring in operators.

- A potential effect on existing sawmillers is the use of chainsaw attachments on their chainsaws to process difficult to access trees, or large logs traditionally halved or quartered for manual extraction to a bench saw.

Analyse relationships between stakeholders

Guidance notes: Are conflicts or mutual benefits occurring or likely to (including with institutions/ powerbrokers)? Who would be the winners and losers? What do stakeholder groups think of one another and how could conflict be reduced? What could be done to improve relationships with institutions. Not assessed

Conflicts were not mentioned except for:

- ❖ The common belief and some evidence that farmers are not being paid fair prices for their trees, with considerable variation noted for similar tree sizes and qualities.
- ❖ Boundary tree ownership.
- ❖ Lack of transparency and knowledge of laws, regulations and permissions on harvesting, conversion, transportation and sale of forest products.

(2) The decision making and participatory forest management context

Much of this section is not assessed in this study as the focus is on the introduction of a 'new' processing technology for East Africa, and not forest management. However, comments are made where there is relevance.

Scope historical land management and factors, seasonality of work and other influences

Guidance notes: As suggested, the history and reasoning of historical land management is assessed. Participatory Rural Appraisal (PRA), aerial photographs, published and secondary information can all be used to do this. In the context of chainsaw milling this could indicate historical influences on the growing, availability and harvesting of timber trees from various sources as well as timber markets. Not assessed.

In the 1930s, Meru District was selected for experiments with the first Kenyan owned coffee plantations. Soon afterwards, due also to pre-Independence conflicts, pulses also became important export crops. By the 1960s, Meru District was considered to be Kenya's leading coffee producer. Tea was introduced soon after but did not become economically important until the 1990s when it became the highest income generator in Meru.

Regarding seasonality, farmers generally only want their trees harvested in the period between crop harvesting and new planting, unless there is alternative access to the tree or they are in very great need of cash. This leads to considerable downtime for sawmillers, chainsaw operators and others in the timber chain.

Prioritise stakeholder decision making criteria in undertaking milling

Guidance notes: This should assist in identifying how important the economics of chainsaw milling are against constraints that are biological (e.g. tree growth rates), technical (e.g. ability to use chainsaw mills), institutional (e.g. laws or regulations pertaining to timber milling and sales) and social criteria. If the constraints are mostly not related to chainsaws and economics, then more focus in the data collection and decision making criteria should be paid to these constraints. Not assessed.

For existing sawmillers, the constraint facing them was the time and so the cost of finding and negotiating the purchase of on farm trees. For new entrants, such as chainsaw owners or operators who may consider purchasing chainsaw milling attachments, the constraint of finding suitable trees will be more difficult still as they are unlikely to have the negotiating skills or network of farmer contacts.

Finding the capital to purchase equipment will be a

considerable barrier, with average earnings under US\$1 per day. Additionally, they will not be experienced in the sale of timber placing further costs and time constraints. As mentioned, lack of transparency and knowledge of laws, regulations and permission for harvesting, conversion, transportation and sale of forest products is a further constraint. The actual use of the chainsaw milling attachments will need some training but may be relatively intuitive for existing chainsaw operators and owners. For new users, the main challenge will be safe chainsaw use, particularly felling as well as sharpening and maintenance.

Identify limiting factors of chainsaw milling

Guidance notes: Are the limits to widespread adoption land, labour or capital within stakeholder groups?

Most factors are limiting within farming stakeholder groups in the growing of timber trees. The average land holding is 3.4 ha and the average household's portion is 1.7 ha (Tyndall, 1996). Muchiri et al. (2000) found densities of 200 trees/ha, principally *Grevillea robusta*, growing at an estimated 8-24 m³/ha/yr. Njuguna (2004) noted that 56% of the trees and 68% of the standing volume in Meru Central District were considered as timber (not fuelwood) trees, 51% were boundary trees (49% of the total volume), 36% were in cropland (37% of the volume), 14% were more than 30cm DBH (59% of the volume), with 82% under 15 years old (43% of the volume). A 1998 survey found 1137 trees per farm, 397 trees/ha, with a standing volume of 20 m³/ha.

Limiting factors for new millers include: capital (at average manual wage rates of US\$1/day, saving all of it would take over 2 years to purchase the equipment), and knowledge of the business (including: chainsaw use, with no training available in Kenya; harvesting techniques, negotiation skills, sales and marketing; laws, regulations and permits; networks of farmers potentially selling trees; and general business skills). The limiting factors for existing chainsaw owners include only some of the above: knowledge of the business; negotiation skills, sales and marketing; laws, regulations and permits; and networks of farmers potentially selling trees.

(3) Cost-benefits of chainsaw milling

Here the first two sub-sections are assessed as they are central to the economic analysis. The latter two are cursorily treated as they could not be followed economically in this study.

Guidance notes: Here the purpose is to quantify where possible, the relative cost and benefits of timber processing with chainsaw milling or without it. Estimates of potential timber production, inventories and growth rates, will often be problematic, even more so where illegal harvesting takes place. Biological growth modelling, stakeholder interviewing, household surveys, Participatory Rural Appraisal (PRA) methods and Participatory Forest Management (PFM) techniques can all be used.

Identify benefits and costs

Guidance notes: The net benefits and costs should be identified, including a measure of the environmental benefits and costs, which are often very difficult and occasionally controversial to assess. The effects on different stakeholders and over time should be included.

Benefits

- ❖ Enabling chainsaw owners to convert trees to timber at similar conversion efficiencies to other mill types, at lower capital cost but likely higher costs per piece.
- ❖ Greater competition for trees may lead to better prices for farmers.
- ❖ For existing chainsaw owners, the 'Alaskan' type frame mill is likely to be popular, as a way to diversify their business from 'chainsaw felling for hire' to 'feller and miller'. In parts of the country where freehand chainsaw milling is common, once the technology is known and buyers offer better prices or demand sized, high quality finished timbers, uptake of such frame mills is likely to be high.

Costs

- ❖ Greater pressure to mill farm trees and milling of trees previously inaccessible such as on steep slopes and in valley bottoms, may risk increased soil erosion.
- ❖ Mobile and static bench sawmillers will come under competitive pressure from chainsaw millers. However, their knowledge network of farmers likely to sell trees and timber yards, through which most timber in Meru appears to be sold, combined with their probable lower variable cost per unit output, will potentially mitigate these effects.
- ❖ The potential to increase unapproved felling of farm trees as there will be more sawmillers to monitor.

Prioritise likely benefits and costs

Guidance notes: This shows where most of the effort in gaining information should be directed and is likely to differ between stakeholder groups.

Aim to collect data on the use of chainsaw mills to construct an economic model. Collect data from key stakeholders – farmers, sawmillers, chainsaw operators and owners.

- ❖ Farmers – species and size tree prices achieved, why, how and when they sell trees
- ❖ Mobile and static sawmillers – tree species and size and prices paid, costs and revenues, inputs, outputs, licences and permissions.
- ❖ Chainsaws - costs and revenues, inputs and outputs, as well as operational aspects.

Where possible, gather indicative information on current, past and future of on farm tree growing, milling and selling in Meru, assessing external impacts. Triangulate information from different sources. Gain an understanding of social issues

impacting the sector. Use secondary data where available for all other aspects.

Estimation of production, labour, cash and capital input levels

Guidance notes: The level of information collected will be determined by the data collection budget, timeframes, secondary sources available and the complexity of the situation. This information will directly feed into an economic assessment. Verifying information directly collected through other sources will help reduce bias or unrealistic estimation levels. Not assessed.

As time and budgets for data collection are generally limited, then efforts should be made to utilise indicative information rather than collect data of more verifiable accuracy. Meru has been much studied in regards to timber processing and natural resource management in a broad context, so there is considerable secondary data available.

Assess sustainability of potential tree removal levels

Guidance notes: If data on tree inventories, growth rates or removals is not available, stakeholder interview methods can be used to assess past, present and future changes with or without chainsaw milling. Not assessed.

Current published data on inventories in or around Meru is lacking. Data has been collected by the FAO and ICRAF but is yet to be published. Lengkeek et al. (2003) indicated tree densities (woody perennials >1.5 m tall) of 1,000/ha of 297 different species including coffee. If, as suggested, coffee cultivars comprised a third of the trees counted, this would suggest tree densities of about 600/ha. *Grevillea robusta* density was estimated at 50 trees/ha, by far the most common timber species, with *Cupressus lusitanica* second at 22 trees/ha. No data was published on age or volume. See previous section for comparative data from Muchiri et al. (2000) and Njuguna (2004).

It was outside the scope of this study to undertake independent inventory or extensive stakeholder interviewing to assess growth or removal rates. A common belief is a skewed age distribution with fewer older trees, e.g. grevillea is seldom seen older than 20 years, but relatively high densities of younger trees, as suggested by the 50-200 trees per hectare for grevillea. Dieback of cypress due to disease or insect attack is common in the district and there is a similar fear for grevillea. The general feeling in Meru amongst stakeholders interviewed is that trees on farms continue to be overexploited. Sawmillers point to the low availability of trees over 30 cm in diameter, saying they have to travel distances of 20 km or more to find good trees, though they also maybe cheaper.

(4) Values and prices

Guidance notes: Values and prices are assessed in this section. The valuation method(s) needs to be decided upon according to the situation and scope of the study, as well as whether both or either of financial or economic analysis will be used.

In this section, analysis is limited to direct quantifiable costs, prices and values. Non-market aspects are only touched upon and no economic analysis is made of them.

Prioritise benefits and decide on valuation methods

Guidance notes: There are a host of valuation methods available to assess economic aspects, particularly complicated non-market benefits that are normally expensive to undertake. They may also be difficult for stakeholders to comprehend and very difficult for them to carry out. Two that are suggested for use in this study and data collection framework are the self-explanatory 'market pricing' and 'opportunity costing', the valuing of (usually) labour by the foregone income that could be earned working for someone else. Not assessed.

Only basic economic information from chainsaw milling and, where available, from other sawmills was collected. With approximately 56% of the Kenyan population living at or below the poverty level on less than US\$1 per day, with an official unemployment rate of 28%, (other sources put it at 40% in 2001), there maybe few other opportunities to gain paid work, especially outside of the major cities. Labourers for the sawyers, including the casual milling personnel, often earned a little less than US\$1 per day (calculated to Ksh67 for a 7 hour day). The associated economic model with this data collection framework, uses a slightly higher rate of Ksh10 per hour.

Value markets - stumpage, levies, concessions, and timber values - construction, furniture and craft

Guidance notes: Gather data and / or secondary information to estimate (give ranges unless no variation in local markets is present) the values of trees and timber. Record species, size, quality price variation, esp. if difference between chainsaw and fixed sawmill differences. Stakeholders may well pay different prices for the same timber, not just based on volume but also cultural or social context, as well as barter. If markets for by-products e.g. for fuelwood, gather this too. Historical information is important, along with inflation and influences, to help inform potential future pricing. Comparison with other land based products such as maize or fuelwood help understanding changes in land use.

The data collected in Meru suggests that about 80% of the trees milled were grevilleia, and an estimated 8% of the species milled are native. When prices paid per tree are

converted into approximate values per unit volume it is clear that farmers are underpaid for large trees. Whenever trees of similar quality are sold by volume, larger trees always fetch a high price per unit volume because of the higher recovery rates gained from larger diameter logs. This clearly supports why trees are sold at a relatively immature age, i.e. it is more economic to do so. Any forester, forest officer, plantation owner or other trained personnel measuring volume could demonstrate that a 30 cm diameter tree has four times the volume of a 15 cm diameter tree of similar form (volume increases at twice the rate of diameter). It is evident that if millers wished to make a better profit, then they should focus on buying bigger trees as not only are they paying less per unit volume, but also gain higher recovery rates.

Table 3.1. Tree species milled in Meru

Latin name	Local (English) name	Species observed %
<i>Grevillea robusta</i>	grevillea/mokua (silky oak)	80%
<i>Cupressus lusitania</i>	cypress/thithinda (Mexican cypress)	5%
<i>Eucalyptus saligna</i>	Eucalyptus (Sydney blue gum)	5%
<i>Cordia africana</i>	Muringa (large leaf cordia)	3%
<i>Vitex keniensis</i>	muuru (Meru oak)	3%
<i>Markhamia lutea</i>	mugwani/moumi (markhamia)	2%
Other species	-	2%

Table 3.2. Prices paid for on farm trees (modelled data)

Trees	Small 12-25 cm dbh	Medium 25-40 cm dbh	Large 40-60 cm dbh
<i>Grevillea</i>	7.04	11.97	25.70
<i>Cupressus</i>	4.93		30.99
<i>Eucalyptus</i>			30.99
<i>Cordia</i>	14.08	28.17	70.42
US\$/m³	@ 0.15 m³/tree	@ 0.64 m³/tree	@ 1.96 m³/tree
<i>Grevillea</i>	46.12	18.61	13.09
<i>Cupressus</i>	32.29		15.78
<i>Eucalyptus</i>			15.78
<i>Cordia</i>	92.25	43.78	35.87

NB. Standing timber is purchased on a per tree basis and not per cubic foot or metre, hence the higher price per cubic metre for smaller trees.

Table 3.3. Local sales value of *Grevillia robusta*

Nominal Size (mm)	US\$/m	US\$/m ³	% milled in Meru
100 x 75	0.92	123.22	2%
75 x 75	0.74	131.44	3%
100 x 50	0.62	124.76	23%
200 x 25	0.60	120.14	10%
150 x 25	0.46	123.22	5%
75 x 50	0.46	123.22	23%
50 x 50	0.37	147.87	25%
50 x 25	0.18	147.87	10%
Average	0.55	132.13	

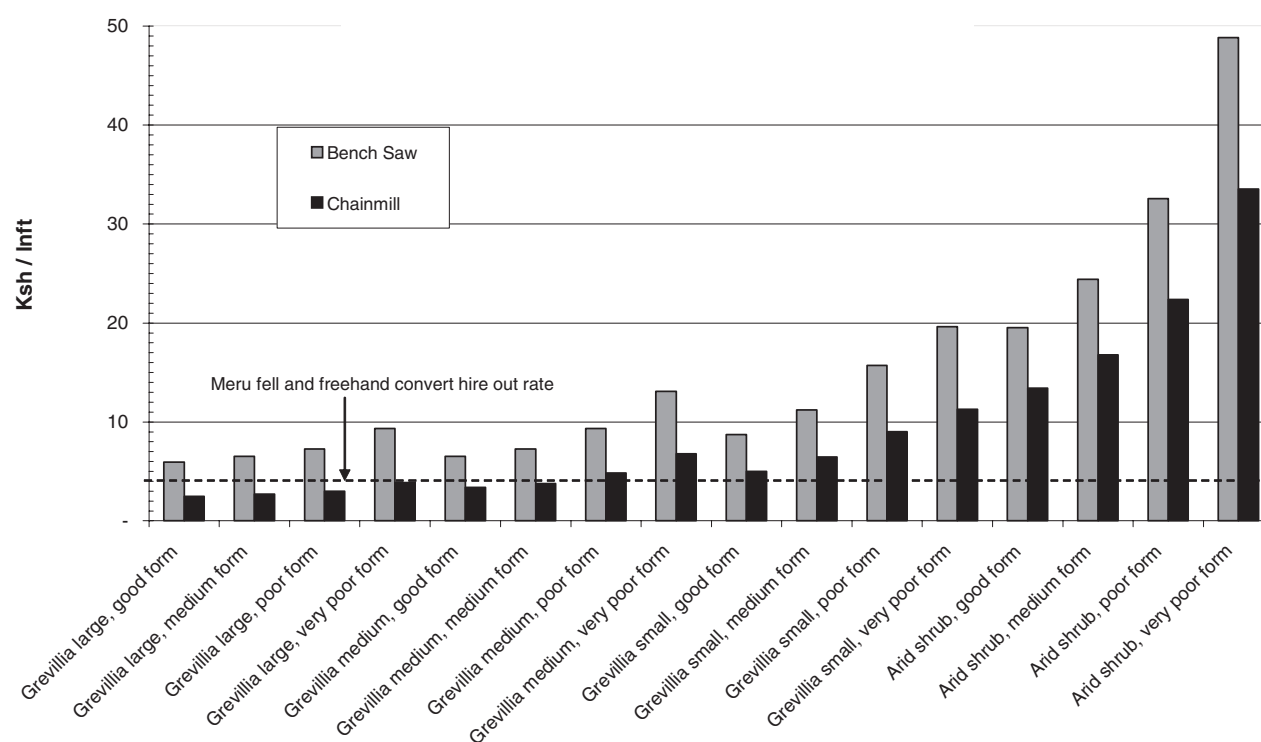
Many trees now being harvested were not planted specifically for timber but for other purposes such as shade. This in part explains why volume measurements are not used and why farmers do not have a 'feel' for the value of their trees, as they have no history in selling them for sawn timber. Additionally, prices can be extremely variable depending on the immediacy of cash need, tree quality and species valuation knowledge of the farmer, accessibility, and what might be termed 'personal ownership', meaning whether they have grown and tended it themselves or see it as a 'free gift' planted by previous owners or generations.

Table 3.4. Felling/ milling hire out rates around Meru.

	Ksh	US\$
Chainsaw felling, delimiting and cross cutting	300/l	\$ 4.23/l of fuel used
Rate for a 5-7 person bench sawing crew - casual, own tractor saw	0.70/ft	\$0.03/m of slab milled
Rate for hired in tractor circular saw and crew	2.50/ft	\$0.12/m of slab milled
Rate for hired in freehand chainsaw milling and operators	2.75/ft	\$0.13/m of slab milled

Fuelwood values were difficult to assess, because farmer home consumption was not valued due to project constraints. In Meru town, sawmill offcuts were sold by a variety of methods, a wheelbarrow full (Ksh100), by the heap (Ksh300-500) or trailer load (Ksh900). Better quality offcuts were sold as fencing or for making market stalls achieving roughly Ksh25 each for 2.3 m or longer. It was reported that the Kenyan Tea Development Agency Limited (KTDA) buys 1m³ of firewood for Ksh150, with the farmer given a 1 m long stick to measure with, if it is assumed therefore that 50% of the stack is air space then the true value is Ksh300/m³ for firewood.

Figure 3.2. Breakeven retail hire out rates inclusive of felling from chainsaw frame milling and mobile bench saw milling for different sized trees of different forms.



Estimate value of home consumption

Guidance notes: Where home consumption is high be cautious of using market prices or opportunity cost (what it would have fetched on the market less transport and marketing labour) as valuation methods. For example, the timber may not have been used at these prices for various reasons including lack of money. Not assessed.

In the tree purchase negotiating process, farmers often retained all firewood remaining after cutting logs to milling length and offcuts if milled on site. The other 'home consumer' was the end-user timber buyer, usually someone buying trees from neighbouring farms or sometimes using their own to construct a house. Here, chainsaw fellers and mobile bench saws were hired in to convert the timber. These end-user buyers give a clue to the cost of trees compared to the market price for sawn timber. Some of those interviewed said they would do it again if they wanted timber, now realising how many trees they would need to produce the building timber due to the 40% or so log to timber conversion rate.

Indicate on-site non-market benefits

Guidance notes: Various valuation methods can be used including ascribing monetary values, e.g. the cost of fertilizers to replace eroded soil. As an indication, the relative ranked importance of non-market benefits by stakeholder groups or individuals compared to market benefits, give a useful idea of the comparative significance of outputs.

Trees are seen and used as a cash reserve for farmers. Principle uses for the 'tree cash' is school fees and uniforms as well as emergencies such as medical expenses. Many of the trees now being harvested were not planted for sawn timber, as before 1999 virtually all sawn timber came from the public forests and plantations. It is understood at the time of planting the trees functions were as follows.

- ❖ Principle uses for trees are animal fodder and firewood. Many trees, and all grevillea are 'pruned' either with the branch still hanging to dry for firewood, or cut fresh for both firewood and fodder. Unfortunately for timber quality, but easier using a machete up a tree, this 'pruning' usually left a long (~15cm) branch stub.
- ❖ Many trees were planted to provide partial shade for coffee. As the coffee price has been low for some time, many farmers have removed the coffee bushes but left the trees.
- ❖ Environmental benefits are seen to be large, for crop shading and protection (wind and heavy rain), for soil stability in the rainy season (particularly soon after crops are planted).
- ❖ Lengkeek et al. (2003) lists a myriad of uses for the woody perennials found on farms. Ones not listed so far include herbal medicines for humans and animals, fruit, ropes, beehives, plant supports, soil fertility, rain attractors,

tooth brush, ornamental, animal traps, tool handles and many others.

Indicate off-site or 'down stream' costs and benefits to secondary stakeholders (National / Social perspective)

Guidance notes: These can be exceedingly important in regional / national policy decisions, especially where the potential for costs or benefits are large. Valuation is often difficult and can be contentious. Not assessed.

Farmers in Kenya have been supplying the majority of sawn timber used within the country since 1999. Though the FAOs 2005 Global Forest Resources Assessment for Kenya tables do not indicate any timber came from non-forests, it is very evident that it does to a large extent. Equally, FAO tables suggest only 160 m³ of timber was imported in 2002, through there is a large trade in timber, often illegally sourced, with Congolese timber freely for sale in Nairobi.

It seems the FAO removal data of 2.4 million cubic metres accounts for the gazetted forest harvesting supplying industrial users, which concurs with information from the Forest Department. This therefore suggests the 84,960 m³ of sawnwood consumed in Kenya in 2002 from the FAO tables comes from outside forests, i.e. farmers. This would also mean that farmer-grown timber is worth US\$24m, or Ksh1.74 billion, if the Meru average market price for sawn timber is used.

The low impact harvesting systems currently used (fell-cut-carry), partly a result of farmers not wanting their crops damaged, means there are few 'downstream' environmental costs in terms of soil compaction or erosion, river silting or turbidity. This maybe marginally further reduced, through milling where the tree fell, rather than carrying the logs out manually to a tractor accessible point. Alternatively, in now converting previously inaccessible trees due to terrain, increased erosion could result from extraction of the sawn wood and firewood.

There is a concern, not with chainsaw milling, but the preponderance of sawn timber deriving from one exotic species, *Grevillea robusta*, believed to come from a narrow genetic pool. This is a risk on a number of levels, principally susceptibility to attack from pathogens or insects. This has recently happened to *Cupressus lusitania*, where dieback has caused considerable tree loss especially in plantations.

There is the potential for increased illegal logging. This is unlikely in Meru Central gazetted forest, as adjacent communities report and investigate any chainsaw noises from the forests, the impact of chainsaws milling is likely to be small. In gazetted forest remote from habitation, there is potential for increased illegal felling and milling using chain mills. However, current estimates of 100 tonnes per month being illegally harvested throughout Kenya suggest the impact will be small. Where illegality is likely to increase is where farm trees are milled without the correct permissions

being sought, as these regulations and permissions are currently unclear to most people.

Indicate comparison of market/ non-market benefits

Guidance notes: Summation of part 5. Not assessed.

This section has shown that the benefits of chainsaw milling are relatively high. Though principally suitable for areas of farm forest where there are few economic milling alternatives, they are also likely to be used as an adjunct to other milling systems for relatively inaccessible trees. Chainsaw milling with 'Alaskan' frames is assessed to be able produce timber profitably from trees over 25cm, with lower capital outlay but likely higher running costs than other conversion systems. Farmers would benefit from the widespread use of frames through the greater competition from more buyers for trees.

End users, especially local furniture makers currently using freehand chainsaw milled timber, will benefit through less planing wastage to produce a finished, flat, straight even thickness boards. This wastage reduction has downstream benefits of less timber, fuel, and money per finished piece.

Non-market/ non-directly measured benefits include

- ❖ employment and small business generation, especially for low skilled landless in rural areas
- ❖ resource development through farmer income generation encouraging planting of more timber trees
- ❖ Import substitution, milling mostly sustainably produced local timber rather than importing often illegally felled (usually judged as unsustainable) timber from moist zone African countries, and contributing to reduced foreign debt
- ❖ Contribution to reduced greenhouse gas production by short distances to market, little travel cost or pollution, and less alternative materials (concrete, steel, plastics) as high users of energy – mostly fossil fuels

Non-market or non-directly measured costs include

- ❖ Higher fuel consumption per cubic metre milled than other methods – higher greenhouse gases
- ❖ Potential to increase unauthorised or illegal milling due to larger number of highly mobile millers being more difficult to monitor.
- ❖ Over-exploitation of farm trees – younger trees milled yielding lower conversion rates, everyone including the miller losing.

Cost or input valuations - opportunity costs, capital costs, depreciation levels

Guidance notes: Include opportunity costs of labour and land where appropriate. Depreciation should account for local conditions (e.g local resale values and longevity), which helps decide on straight line or declining value depreciation and a decision made on whether to depreciate on purchased cost or replacement cost. Spares costs and likely need should also be localised where possible. The cost of capital (or money) is likely to be localised and may involve non-monetary transactions (e.g. labour, sawn timber, firewood, animals). Transaction costs (e.g. applying for permits, attending meetings, negotiation etc. as well selling trees /timber) can be large and should be assessed.

No data on the price of land or its opportunity cost was gathered in Meru, nor have secondary sources read reported it. Meru is seen as one of the most favoured farming regions in Kenya, 'Meru farmers never starve'.

Mobile bench saw mills comprise of 30-40 hp tractors, 20 or more years old and locally made bench saws. Millers when asked of re-sale values and longevity of equipment often suggested a further 20-40 years with regular maintenance.

Chainsaw owners gave two accounts of the replacement cycle and maintenance of chainsaws, the first being owner operators or supervised operators using chainsaws often for 8 years or more with regular maintenance. The second was owners employing unsupervised operators, indicating that chainsaws had to be replaced every 2-3 years and that after about 18 months (see box on the next page), replacement pistons were regularly needed.

Labourers for chainsaw and bench saw millers, including the casual milling personnel, often earned a little less than US\$ 1 per day (calculated to Ksh 67 for a 7 hour day). The associated economic models with this data collection framework, uses a slightly higher rate of Ksh10 per hour. The models include the owners' labour also at Ksh10 per hour.

None of those interviewed borrowed money from financial institutions, utilising savings or extended family borrowing. For the financial model that accompanies this study, a interest rate of 16.5% was used for borrowed money. This was derived from the cost of a 'Motor' loan from the Commercial Bank of Africa, 5% above the base rate of 11.50%. However, the average lending rate in December 2005 from the Central Bank of Kenya was 13.2%. This was rejected as it was an unlikely rate at which low income or asset poor people could borrow at. The exchange rate in February 2006 was Ksh71=US\$1, used throughout.

There are two sets of what can be loosely described as transaction costs. The first set is searching for and negotiating with farmers for trees along with the associated felling

Table 2.5. Respondent equipment valuations, longevity and depreciation

Valuation and depreciation on capital items (US\$)	Tractor (25-35 hp) 20-30 years old	Mobile bench saw (locally made)	Static bench saw	Alaskan frame (all estimated)	Chainsaw (often Husqvarna 272)	
					Supervised	Unsupervised
Value at purchase	14 085	7 042	8 451	370	732	732
Lifetime (years)	30	30	40	12	6	3
Residual value (estimated)	4 225	282	282	70	70	141
Depreciation (Fixed declining balance) US\$ / per year						
Year 1	549	718	693	48	237	310
Year 2	528	645	636	42	160	179
Year 3	507	579	584	36	108	103
Year 4	488	520	536	32	73	
Year 5	468	467	492	27	50	
Year 6	450	419	452	24	34	
Year 7	433	377	415	21		
Year 8	416	338	381	18		
Year 9	400	304	350	16		
Year 10	384	273	321	14		

permits and transport licences. This was assessed in Meru to amount to 3.5 hours per day of milling for static and mobile mills, but only 2.5 hours per day of milling with chainsaw mills due to lower production and so tree demand. The second set is for the cost of maintaining a timber sale yard with the associated labour costs, rental and local taxes. This

is likely to be needed for any business selling volumes of timber at retail prices, unless a different model of selling to timber yards is adopted along with lower prices achieved.

A further advantage of a timber yard is that farmers can approach the yard to sell trees, reducing the first set of

Notes on chainsaw (mis)use – how life is reduced for both operator and chainsaw

It is common practice to use a 10:1 (10%) ratio of petrol to two-stroke oil in Meru rather than the manufacturers recommended mixture ration of 33:1 (3%). The usual measure is 5 litres of petrol to 0.5 litres of 2 stroke oil. This not only literally burns money (Ksh14/day) for no purpose but also causes ‘coking’ of the engine, whereby the unburnt oil forms in a crusty layer in the engine and exhaust system. This reduces the power and performance of the engine. It is also common practice to alter the fuel air mixture adjustment screws, partly as a response to the ‘coking’, but also in the belief it produces more power if the engine goes faster. By adjusting the factory set mixture screws, the mixture often becomes ‘leaner’ meaning the engine uses more air to petrol than it is designed for, causing excessive heat, in turn burning holes in the top of pistons and causing other mechanical failures.

Additionally, all chainsaw users remove the depth gauges on the chain of the chainsaw, thinking it will cut faster by producing bigger chips, which it does. With the depth gauges removed, operators cannot use the full length of the bar because it would stall the engine, only the tip. However, using the tip of the chainsaw vastly increases the incidence of ‘kick-back’, where the chainsaw bar tip catches in the timber flipping the end of the chainsaw upward, usually to the operators head or arms, cutting both or either open. Removing the depth gauges also vastly increase vibration, causing fatigue to both operator and chainsaw. Vibration such as this can causes ‘white finger’ (more common in colder countries where hand blood supply is reduced), which permanently damages nerve-endings in the fingers so touch and other functions are lost.

transaction costs. Yard rentals in Meru are about Ksh60,000 per year (US\$845/yr) a full time worker for 7 hours a day, 5 days a week at Ksh10 per hour will amount to Ksh16,100 per year (US\$227/yr) whilst the annual sawmill licence is about Ksh6,000 per year (US\$85/yr).

(5) Results and performance measurement

Guidance notes: The purpose of this section is to provide economic assessments to allow decisions to be made and assess the criteria and risk used to form the judgement. The stakeholder groups will focus on what is useful or important to them. Therefore farmers will likely concentrate on whether it is more profitable to mill your own trees for timber sale or to sell the tree. For policy makers and institutions the assessments is more likely to focus on the wider social and environmental benefits and costs.

Again, in this section, analysis is limited to direct quantifiable costs, prices and values. Non-market and regional aspects are only touched on and no economic analysis is made of them. The following information is based on two spreadsheet models approximating conditions and information gathered in Meru. All information excepting much for the chainsaw mill, was predominantly collected by personal interview verbal recall, as no records seemed to be kept. This information was combined to reduce variation. The data gathered on chainsaw milling was through direct observation, timings and volume measurements and so is likely to be much more accurate, though biased in its setting.

The two spreadsheet models allow for four different tree sizes and qualities. However, because of the volume of this generated information (32 combinations), all the following

presented analysis is based only on medium sized grevillea, (av. 32 cm DBH, 0.64m³), of good quality. This is a fair representation of many of the trees milled in Meru, though it might be argued that many of the trees are perhaps a little smaller in diameter, 28cm DBH, and perhaps of a little lower quality. The models also allow for many variations, some of the ones chosen for presentation here are; all finances are assumed to be borrowed @ 16.5% APR, depreciation has been described previously. 150 milling days are assumed to be worked per year, with a recovery rate for good form medium sized trees of 50%, producing (chainsaw mills 139m³/yr, mobile bench saws 218m³/yr) 100 x 50 mm timber at Meru prices of Ksh13.50 per running foot.

For the chainsaw mill, it has been assumed that small trucks are hired in to transport the sawn timber, whereas the mobile bench saws tows the timber away with a trailer. Both models assume that the trees are felled, prepared and cut to length for milling by the crew operating the mills, these costs are included in the models. Data used and assumptions for much of the models and graphical representation are in Appendix 2. The models are available on <http://chainsawgwork.org>.

Gross margin, net income, breakeven analyses where possible (cost and returns not discounted)

Guidance notes: In many cases of farm forestry, where decisions are between selling the tree or hiring a chainsaw miller, simple analyses are appropriate. Gross value, net income and Gross margin by labour, land and potentially cash or capital. Where large farmers may consider their own equipment or for contract chainsaw millers, analysis of the breakeven income is also useful along with cash flow analysis.

Table 3.6. One year returns from chainsaw frame milling and mobile bench saw milling with good quality medium sized trees.

Chainsaw frame milling		Results	per hour	per unit of	per m ³
			of labour	currency invested in capital	of log milled
Total first year costs	Ksh	882 036	204	11	3 354
	US\$	\$ 12 423	\$ 2.87	\$ 11.27	\$ 47.24
Gross income first year	Ksh	1 164 862	269	15	4 429
	US\$	\$ 16 407	\$ 3.79	\$ 14.88	\$ 62.38
Gross margin first year	Ksh	282 826	65	4	1 075
	US\$	\$ 3 983	\$ 0.92	\$ 3.61	\$ 15.15
Mobile bench saw milling					
Total first year costs	Ksh	1 685 648	154	1.09	3 875
	US\$	\$ 23 742	\$ 2.16	\$ 54.58	\$ 54.58
Gross income first year	Ksh	1 926 673	176	1.24	4 429
	US\$	\$ 27 136	\$ 2.47	\$ 62.38	\$ 62.38
Gross margin first year	Ksh	241 025	22	0.16	554
	US\$	\$ 3 395	\$ 0.31	\$ 7.80	\$ 7.80

Chainsaw frame milling is likely to give healthy returns if trees of medium size (average diameter 32 cm diameter at breast height (DBH)) and good quality are milled, for example the gross margin on capital invested is 360% (US\$1 invested yields US\$3.61). However, when the tree size drops to small (average diameter 18 cm diameter at breast height (DBH)), losses are modelled to be made. The returns for an hour of all labour in the business are 6 fold (at Ksh10/hour) for chainsaw mills and 2 fold for bench saws. However, labour costs are a small portion of overall costs as will be seen in the sensitivity analysis.

As most mobile bench sawmillers have owned their equipment for some time, many of them would not owe any of the capital and so not pay any interest (16.5%). Given this situation, the gross margin in the first year rises to nearly Ksh586,848 or US\$8,265 and the return on capital 38%. Alternatively, the poor result could stem from incorrect assumptions, calculations or poor quality of the data gathered.

The modelled margins per cubic metre of log milled again shows the chainsaw mill performing twice as well as the bench saw, the difference being the costs incurred by the bench saw. These costs in-part derive from the cost of borrowing capital and if mobile bench saw owners have already paid for the equipment their gross margin rises to Ksh1349 or US\$19.00/m³ of log.

The valuation and revenue data for these tables is nominally based on the conversion of logs to 100 x 50 mm timbers achieving Meru market prices of Ksh13.50 per running foot or US\$124.76/m³. It can be seen that for the tree type modelled here, the chainsaw mill, where the full capital is borrowed, is likely to make Ksh3.28 (13.50-10.22) from every foot sold (US\$30.29/ m³ sold).

Conversely, the model suggests when borrowing the finances for capital, bench saws make Ksh1.69 per foot sold (US\$15.60/m³). When the finances are not borrowed, the margin rises to Ksh4.11 per foot. When examining the hire out rates, bench saw appear to need nearly twice the rate of chainsaw mills per linear foot to breakeven. When operators with chainsaw milling attachments are hired out, the model suggests breakeven rates of Ksh3 per foot. The rates two respondents were able to give for freehand chainsaw milling in Meru, which rarely happens, was understood to be Ksh2.75 for milling only and Ksh5 per running foot believed to be inclusive of felling.

The breakeven on operating the business (milling and selling timber) indicates the numbers of days milling that are required to cover all the costs of the business. For the chainsaw mill set-up this is 114 days whilst the bench saw tractor combination requires 131 days. Starkly, the bench saw requires the equivalent of 6.75 years to repay the capital invested against the much better performing chainsaw payback period of just 101 days, two-thirds the number of milling days envisaged in the model, 150.

Figure 3.4. Breakeven analysis from chainsaw frame milling and mobile bench saw milling for different sized trees of different forms.

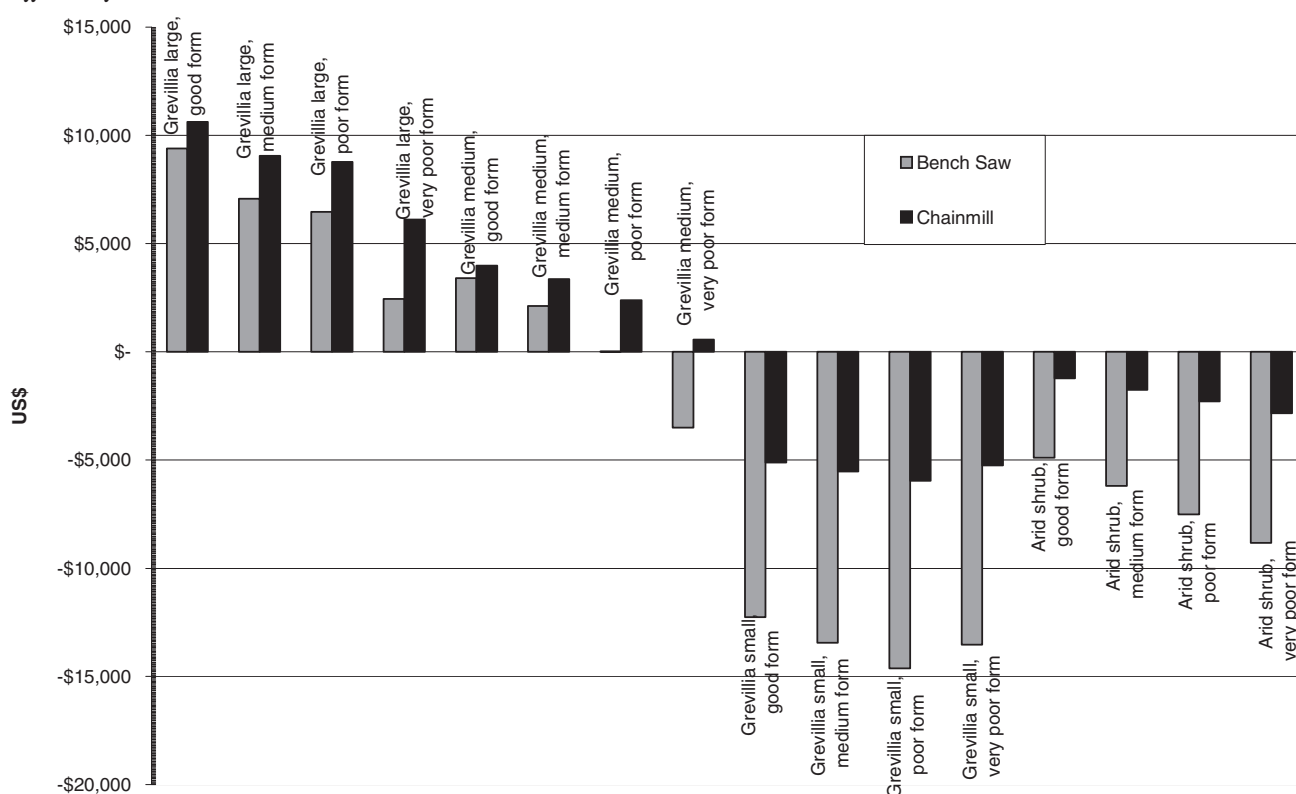
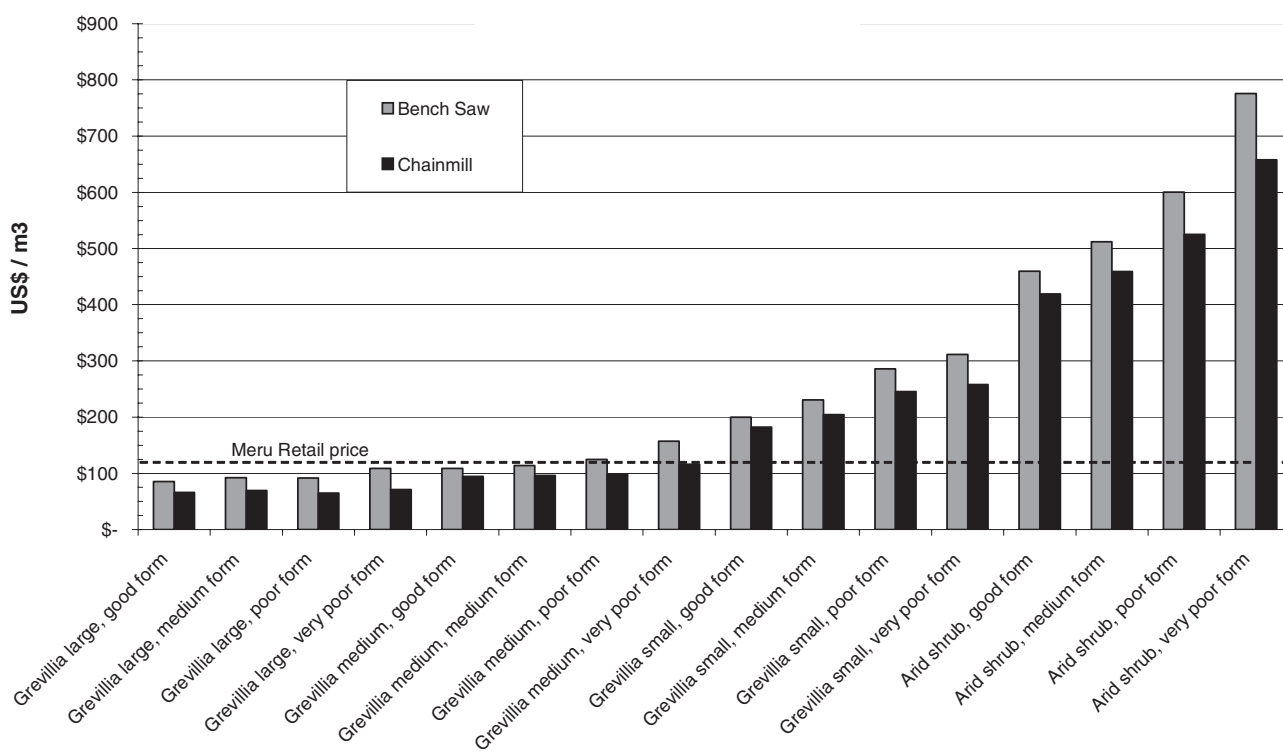


Table 3.7. Breakeven analysis from chainsaw frame milling and mobile bench saw milling with good quality medium sized trees.

Chainsaw frame milling			
Breakeven yard timber price		per m ³	per linear foot
	Ksh	6 708	10.22
	US\$	\$ 94.47	\$ 0.14
Breakeven hire out rates		per litre of fuel used	per linear foot
	Ksh	208	3
	US\$	\$ 2.93	\$ 0.05
Breakeven milling and selling timber (days)		114	
Payback period on frame milling and selling (days)		101	
Mobile bench saw milling			
Breakeven yard timber price		per m ³	per linear foot
	Ksh	7 750	11.81
	US\$	\$ 109.16	\$ 0.17
Breakeven hire out rates		per litre of fuel used	per linear foot
	Ksh	1 131	7
	US\$	\$ 15.94	\$ 0.09
Breakeven milling and selling timber (days)		131	
Payback period on equipment from gross margin (years)		6.44	

Figure 3.4. Breakeven analysis from chainsaw frame milling and mobile bench saw milling for different sized trees of different forms.



Discounted cost-benefit analysis (CBA) methods if applicable and possible - Net Present Value, Internal Rate of Return, Benefit-Cost Ratio

Guidance notes: Discount rates (see economic measures worksheet) can be potentially difficult to assess from the low income stakeholder information and perspective as discount rates (the current value of a future sale) are difficult to separate from inflation and are related to the perception of risk. However, if there are options for the growing timber tree (e.g. sale/use now as firewood or conversion to sawn timber in a number of years time) then an assessment is difficult to avoid. Discount rates for project investment by government or development agency will often be much lower than stakeholder rates. Here comparison on different project NPV's, IRR's and BCR's is made to decide where to invest resources.

As the gross margin on capital invested indicated for chain mills in the previous section, the Internal Rate of Return (IRR) is very good at 261% in the first year rising to a plateau

of 362% by the fourth year. Internal Rate of Return or IRR is often used in capital budgeting, it's the interest rate that makes net present value of all cash flow equal zero.

Essentially, this means IRR is the return that a company would earn if they invested in themselves, rather than investing that money in a bank, so IRR returns anywhere near bank rates are judged as poor investments. Mobile bench saws appear to perform very poorly from an investment point of view, with negative returns for the first five years to produce just 7% by the end of the modelled period, year eight. Clearly, businesses would be better investing the capital deployed in the business into a bank.

The Net Present Value (NPV) brings the future expenditure and income into today's value, depending on the discount rate used (how much less something is worth in the future than it is now). NPV is a way different 'projects' are compared to one another by taking account of differing capital, cash flows and lifetimes. The future stream of benefits and costs are converted into its equivalent values today. This is done

Table 3.8. IRR and NPV Chainsaw from chainsaw frame milling and mobile bench saw milling with good quality medium sized trees.

Chainsaw frame milling

Internal rate of return (IRR)

1st year	2nd	3rd year	4th year	5th year	6th year	7th year	8th year
261%	344%	359%	362%	362%	363%	363%	363%

Net present value (NPV)		Discount rate				
		12%	16%	20%	24%	28%
Gross margin	Ksh	1 405 538	1 245 038	1 094 139	969 901	866 723
	US\$	\$ 19 796	\$ 17 536	\$ 15 410	\$ 13 661	\$ 12 207
Costs	Ksh	4 206 411	3 694 955	3 259 156	2 900 855	2 603 235
	US\$	\$ 59 245	\$ 52 042	\$ 45 904	\$ 40 857	\$ 36 665
Revenue	Ksh	5 786 616	5 059 685	4 469 762	3 985 252	3 582 875
	US\$	\$ 81 502	\$ 71 263	\$ 62 954	\$ 56 130	\$ 50 463

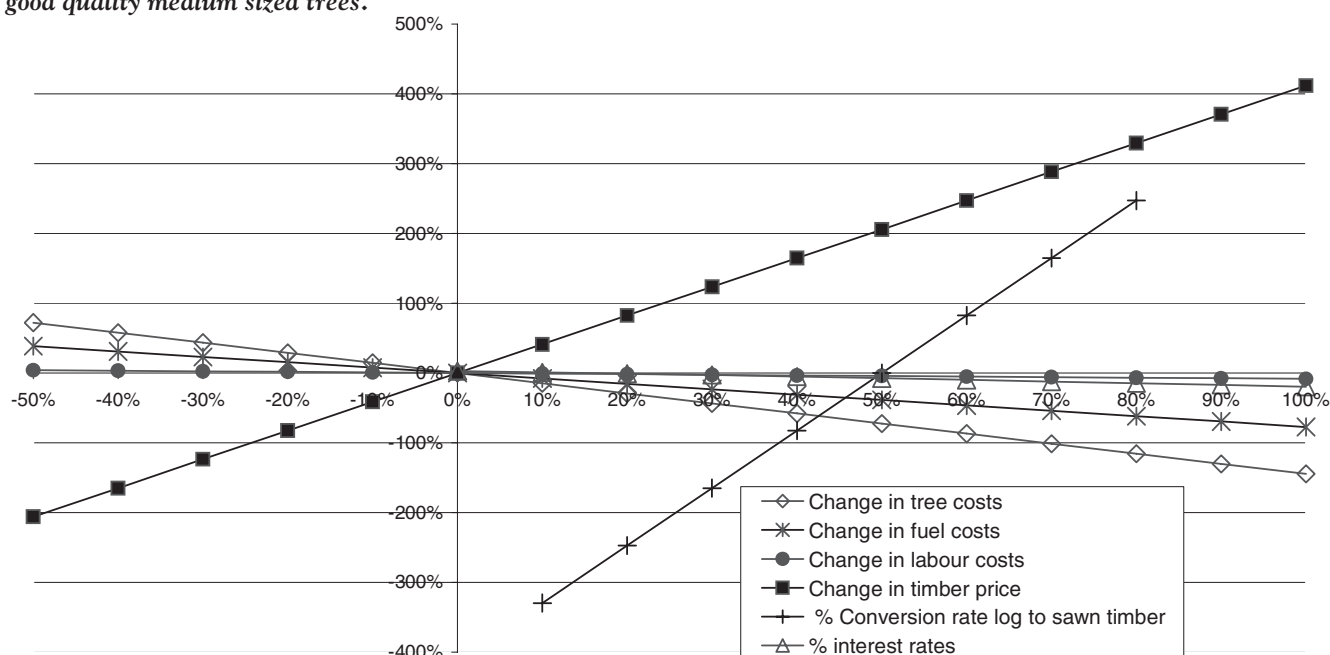
Mobile bench saw milling

Internal rate of return (IRR)

1st year	2nd	3rd year	4th year	5th year	6th year	7th year	8th year
-84%	-51%	-28%	-15%	-6%	0%	4%	7%

Net present value (NPV)		Discount rate				
		12%	16%	20%	24%	28%
Gross margin	Ksh	179 982	37 594	214 163	359 181	- 479 615
	US\$	\$ 2 535	-\$ 529	-\$ 3 016	-\$ 5 059	-\$ 6 755
Costs	Ksh	6 287 036	5 302 274	4 503 116	3 846 758	3 301 664
	US\$	\$ 88 550	\$ 74 680	\$ 63 424	\$ 54 180	\$ 46 502
Revenue	Ksh	9 571 019	8 368 680	7 392 953	6 591 577	5 926 049
	US\$	134 803	\$ 117 869	\$ 104 126	\$ 92 839	\$ 83 465

Table 3.9. Sensitivity analysis as a percentage change in first year gross margin, from chainsaw frame milling with good quality medium sized trees.



by assigning monetary values to benefits and costs, discounting future benefits and costs using an appropriate discount rate, and subtracting the sum total of discounted costs from the sum total of discounted benefits.

Calculating a discount rate to use is debatable depending on the situation. One method for businesses is to use the real interest rate and add inflation. The real interest rate has proved difficult to find but is often 2-6% below the average lending rate, which in December 2005 was 13.2% whilst the interest rate on the 91-day treasury bill was 8.07% from the Central Bank of Kenya. The year on year inflation in February 2006 was 10.88% also from the Central Bank of Kenya, therefore a 20% Discount rate has been decided on.

The NPV calculations used assumed the capital payment for equipment was at the beginning of the financial assessment and excludes depreciation costs. Using a discount rate of 20%, the chain mill performs well, whereas the mobile bench saw has a modelled negative NPV at just a 16% discount rate. When capital costs assumed paid off, the gross margin NPV at a 20% discount rate is Ksh1,112,814 (US\$15,673), very similar to the chain mill with full borrowing costs. Clearly again, the modelled NPV and its sensitivity, demonstrate the poor business case of investing in a mobile bench saw-tractor combination, whereas the chainsaw mill appears a profitable enterprise.

Sensitivity analysis, risk assessment, entrepreneur decision matrix where possible

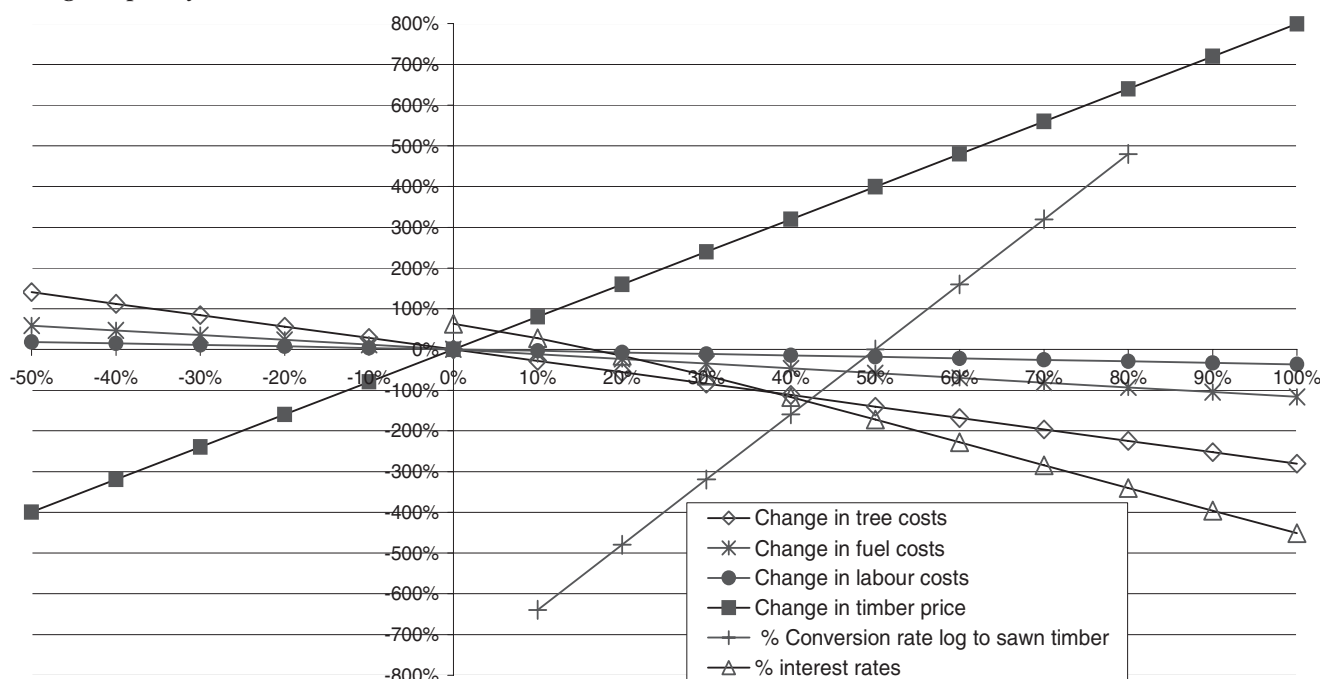
Guidance notes: Risk and uncertainty comes from both the reliability of the data used to make decisions and what may or may not happen in the future. A number of methods can be used, the most common being sensitivity analysis and break-even production levels. Previous steps should have identified actual and perceived risks.

Sensitivity analysis allows assumptions to be tested and in some ways negates their effects as identification of the critical aspects to profitability can be judged. It is presented here as the percentage change in first year gross margin with a change in the aspect investigated (the factor also as a percentage). Sensitivity analysis modelled for chainsaw mills demonstrates a number of aspects by order of magnitude.

Greatest sensitivity is seen in the conversion rate or recovery rate of log to timber. This is though effectively on a different scale, along with interest rates, to the other factors, and is directly related to the timber price achieved. All sawing systems are likely to show such sensitivity (in scale rather than magnitude), hence its critical nature in sawmilling and value choice for spreadsheet models. The recovery rate from both chain mills (observed) and mobile bench saws (estimated from Onchieku 2001) for the specified trees in the models was 50% log to sawn timber. If the recovery rate of 40% for chain mills, as reported for freehand milling by Onchieku (2001), was used this would see the gross margin drop by 82%, to Ksh50,909 (US\$717) from Ksh282,826 (US\$3,983).

Change in (sawn) timber price naturally directly effects the revenue gained and so the gross margin. Just a 5% change in

Table 3.10. Sensitivity analysis as a percentage change in first year gross margin, from mobile bench saw milling with good quality medium sized trees.



sawn timber price for example would change the gross margin by 21%, gaining or losing Ksh59,393 (US\$836.53) from first year gross margins. For potential chain millers thinking of not having their own timber sales yard but selling milled timber to existing timber yards, this shows it will be of critical importance to achieve the best possible wholesale price. Variability in Meru in the price of a running foot of 100 x 50 mm Grevillea from the model chosen Ksh13.50, is similar to the sensitivity change of 5% giving Ksh12.83/ft and 5% more giving Ksh14.18/ft.

Gross margin is relatively insensitive to tree costs as a 10% change in tree costs leads to just a 14% change in Gross margin, i.e. for every extra Ksh100 paid for a tree the gross margin drops by Ksh145. However, the perception in Meru is that tree costs are a major factor in the profitability of sawing enterprises. This sensitivity analysis suggests that more focus should be paid to achieving the highest recovery rates (perhaps by not using unskilled and unmentored casual labour) and the best price for the sawn timber (sales and marketing effort along with straight even dimensioned timber).

Gross margin is also relatively insensitive to fuel costs, as a 20% rise in them will lead to a likely 15% drop in gross margin.

Due to the high level of revenue comparative to the small interest payments on capital, the gross margin is somewhat insensitive to changes in interest rates. A 100% rise in interest rates, meaning a change from 16.5% to 33%, would lead to just a 19% drop in gross revenue.

Labour costs make little difference to the gross revenues achieved for chain mills, where the model uses just two

people to fell, mill and extract the sawn timber. This would suggest employing the best people to achieve the highest recovery rate of log to sawn timber would be a good investment.

Sensitivity analysis modelled for tractor mobile bench saw combinations demonstrates a number of aspects by order of magnitude.

As with chainsaw mills, the greatest sensitivity is seen in the conversion rate or recovery rate of log to timber. However, it is nearly twice as sensitive as chain mills. This is though effectively on a different scale, along with interest rates, to the other factors, and is directly related to the timber price achieved. The recovery rate from both chain mills (observed) and mobile bench saws (estimated from Onchieku 2001) for the specified trees in the models was 50% log to sawn timber. If the recovery rate of 30% for mobile bench saws was used, as reported for unskilled labour by Onchieku (2001), this would see the gross margin drop by 320%, into significant losses.

Change in (sawn) timber price naturally directly effects the revenue gained and so the gross margin. Just a 5% change in sawn timber price for example would change the gross margin by 40%, once again nearly double chain mills, gaining or losing Ksh96,410 (US\$1,358) from first year gross margins. This shows the critical importance in achieving the best possible price. Variability in Meru in the price of a running foot of 100mm x 50mm grevillea from the model chosen Ksh13.50, is similar to the sensitivity change of 5% giving Ksh12.83/ft and 5% more giving Ksh14.18/ft.

Due to the high level of capital and so interest rate costs comparative to the revenue, the gross margin is very sensitive

to changes in interest rates. A 100% rise in interest rates, meaning a change from 16.5% to 33%, leads to a massive 451% drop in modelled gross revenue. Even a 20% rise in interest rates to 19.8%, a quite possible change, would mean losses for a business which had borrowed the capital to buy the tractor, mobile mill and felling chainsaw.

Gross margin is sensitive to tree costs as a 10% change in tree costs leads to a 28% change in Gross margin, i.e. for every extra Ksh100 paid for a tree the gross margin drops by Ksh281. This echoes the perception in Meru is that tree costs are a major factor in the profitability of bench saw enterprises.

Gross margin is relatively insensitive to fuel costs, as a 20% rise in them will lead to a likely 23% drop in gross margin.

Labour costs make little difference to the gross revenues modelled as achieved for mobile bench saws, where the model uses 7 people to fell, extract logs and mill the timber. This, along with the extreme sensitivity to recovery rates, would again suggest employing the best people to achieve the highest recovery rate of log to sawn timber would be a good investment.

Other economic decision making criteria – national or regional

Guidance notes: This effectively provides the initial aspects of a decision support tool through multiple criteria analysis (MCA) or similar, assessing chainsaw milling from a National or regional perspective and for decision makers. It can be both quantitative and qualitative, though bias can be problematic in qualitative weighted scoring of selected criteria. Not assessed.

Multi-criteria analysis describes a number of different techniques to assess complex decisions involving monetary and non-monetary criteria. Multi-criteria analysis (MCA) is used for the appraisal of options for policy and other decisions, including but not limited to those having implications for the environment. It covers a range of techniques which can be of practical value to public decision makers and are increasingly being used around the world (see Anon 2001 for an on-line manual on MCA).

However, they are complex time consuming studies, often using weighted voting techniques to include opinion, or decide on action, from the public and or stakeholders. They can be used in situations where great diversity of opinion is present, sometimes being criticised as a way for policy makers to avoid condemnation from groups or the public. They are sometimes criticised as being made biased, intentionally or unintentionally, through the setting of objectives or options, despite transparency in the actual process of decision making.

Chapter 5 takes the reader through the process of a limited Multi Criteria Analysis (MCA) or Multi Criteria Decision Analysis (MCDA) techniques examining potential policy options to “enable national forest administrations to

determine the conditions under which chainsaw milling is appropriate and sustainable”.

Indicative analysis of scale impact of chainsaw milling on local, regional and national resources, inputs, policies and regulations

Guidance notes: Here an additional step is added to indicate the potential consequences of widespread adoption of chainsaw milling. Not assessed.

The economic assessment, through the models, has indicated that there is great potential for chainsaw milling to be widely adopting as it out performs mobile bench saws. Even when all the capital is borrowed for chainsaw mills and none for mobile bench saws, chainsaw mills are still competitive. Two further aspects will determine the spread, the first being the spread of knowledge that such attachments exist and work well, and the second that blacksmiths or metal workers make local versions of these simple tools, reducing the price and overcoming lack of importing agents or companies.

The effect in Meru, following a demonstration/ training course in February 2006 could be rapid if metal workers make local versions. This will be because the people attending the workshop included a number of chainsaw operators and owners, the first time they commented, any training or other courses had been held for them. With widespread adoption, pressure on farm trees will be high, as it is unlikely that much business planning on tree availability, sales or marketing will be made.

Production of data collection framework

Guidance notes: In each situation analysed, the data collection framework produced will need to reflect the resources available for the study, the context and purpose of the study and the secondary information available. In this case study, with very limited funds, the primary outputs are a data collection framework and decision support tool, the secondary an assessment of the situation in Meru, Kenya. This necessitates some reliance on secondary information, with no primary Participatory Rural Appraisal (PRA) or Participatory Forest Management (PFM) data as they are not necessary for a technological assessment whereas they would be needed for a forest management assessment, with only individual interviewing to gather saw milling information, triangulate and verify secondary data.

Recommendations and summary

Guidance notes: In concluding, the limitations and likely veracity of the study must be assessed along with the results and recommendations. As with all processes, improvements can be made and these must also be indicated.

This study should give a true ‘snapshot’ of chainsaw and mobile bench saw milling economics in Meru given three

limitations:-

- ❖ Finances and time was constrained, leading to less than ideal numbers of interviews.
- ❖ The data collected on the use of chainsaw mills was based on limited sawing in an artificial setting as they have not been used in Kenya before. Accurately collected and utilised data from chainsaw use is needed for verification.
- ❖ None of the timber operations in the area keep records, nor are volume measurements used in log input or sawn timber outputs, only tree diameter and length, and for sawn timber its dimension per foot length. All information was verbally recalled and would sometimes change when 'check' questions were used to attempt accuracy. Volumes were 'back' calculated from in-yard log measurements and sawn timber piece counts. Farm visits verified tree volumes but questioned log values.

Further studies using this methodology would require a minimum of 10 person weeks for both preparation and data collection. Within data collection at least 6 should be interviews with operational stakeholders and at least 4 person weeks should be allocated to assess on-ground performance of a 'new' technology. Report production, economic models data analysis as well as secondary data collection and synthesis, would require a further 12 person weeks of work.

For the return of data to stakeholders, result triangulation and participatory monitoring considerable extra time would be needed, six weeks plus four for reports and materials. . If Participatory Forest Management (PFM) or Multiple Criteria Analysis (MCA) were used a minimum extra 50% time is estimated is would be needed for each component. to complete a similar study to this following the same steps should have been allocated 32 weeks not 9 as this study was. To follow all the steps indicated would take an estimated 66 person weeks. As mentioned before the models are based on a number of assumptions which with additional resources could have been explored.

(6) Implementation, monitoring, improvement

Guidance notes: As the purpose of Economic Stakeholder Analysis is to provide information to assist stakeholder decision making, the information and analysis should be provided in a useable form. Discussions with stakeholders, in particular concerning the economic analysis, are important to check the assumptions used and aid in the understanding of the analysis. As with all projects, monitoring and reviewing improves the process, results and implementation.

The three principle parts of this stage on the data collection frameworks and decision support systems were not assessed in this study, being:

- ❖ Return data to primary stakeholders and discuss how this can contribute to their decision making
- ❖ Verify or triangulate the results with stakeholders
- ❖ Establish a participatory monitoring system

Summary conclusions to the Meru case study

Institutional factors

The new 2005 Forest Act will create a number of barriers to access plantation timber which will be available for sustainable harvest from gazetted forests. The barriers are that to bid for concessions, licences or contracts, it is required that management plans and Environmental Impact Plans or statements (EIS) are drawn up. This will be outside the believed ability of millers in the district. The act also envisages the formation through community participation of 'community forest associations', who amongst other aspects may have the right to harvest timber. It would therefore appear that the only way local millers may gain access to timber from the local gazetted forests is through joining or forming a 'community forest association' such that the pre-requisite plans and assessments can be economically produced.

Lack of transparency and knowledge of laws, regulations and permissions on harvesting, conversion, transportation and sale of forest products causes a variety of problems and difficulties, all with potentially serious consequences:

- ❖ An open door for corruption
- ❖ Discouraging farmers from planting and tending trees for sale as firewood, charcoal or sawn timber
- ❖ Constraining small processors due to risks over the application of laws
- ❖ Encouraging people to think that breaking the law regarding trees and forests is acceptable because 'everyone does it'.

Environmental factors

Chainsaw mills may exert greater pressure to mill more farm trees causing negative effects. Also, the felling and milling of trees previously inaccessible using bench saws such as those in valley bottoms, may risk increased soil erosion. There may be an increase in unapproved felling of farm trees as there will be more saw millers to monitor.

The environmental benefits of trees on farms by farmers are seen to be large, for crop shading and protection (wind and heavy rain), for soil stability in the rainy season (particularly soon after crops are planted). The low impact harvesting systems currently used (fell-cut-carry), partly a result of farmers not wanting their crops damaged, means there are few 'downstream' environmental costs in terms of soil compaction or erosion, river silting or turbidity. This maybe further reduced through milling where the tree fell rather than carrying the logs out to a tractor accessible point.

There is a concern, not with chainsaw milling particularly but the dependence on sawn timber deriving from a single exotic species, *Grevillea robusta*, also believed to have come from a narrow genetic pool. This is a risk on a number of levels, principally in susceptibility to attack from pests, such as recently occurred with cypress aphid attack on *Cupressus*

lusitania caused considerable dieback and tree loss especially in plantations.

Non-market factors

There are potential positive and negative non-market consequences of chainsaw mills.

Non-market benefits include:

- ❖ employment and small business generation especially for the low skilled rural landless
- ❖ resource development, farmer income generation encouraging planting of more timber trees
- ❖ Import substitution, milling mostly sustainably produced timber rather than importing timber, often illegally felled from humid tropical forests, and contributing to reduced foreign debt.
- ❖ Contributes to reduced greenhouse gas production by shorter distances to market and reduced travel cost and pollution, also less use of alternative materials (concrete, steel, plastics) that require more energy for their production.

Non-market costs include:

- ❖ Higher fuel consumption per cubic metre milled than other methods – higher greenhouse gases
- ❖ Potential to increase unauthorised or illegal milling due to larger number of highly mobile millers being more difficult to monitor.
- ❖ Over-exploitation of farm trees – younger trees milled yielding lower conversion rates, everyone including the miller losing.

Stakeholder factors

Farmers will benefit in two ways; from more competition for trees and so potentially better prices as well as being able to sell previously inaccessible trees. Historically, many of the trees now being harvested were not planted specifically for timber but for other purposes, as before 1999 more sawn timber came from the public forests and plantations. Farmers lose out as they don't sell trees by volume measurement and so are losing money on larger trees as the volume of a tree rises at twice the rate as diameter, not in parallel as the Meru prices suggest. Farmers would benefit from the widespread use of chainsaw milling attachments through the greater competition from more buyers for trees.

To landless semi-skilled/unskilled and unemployed young men, chainsaws are already seen as a future path for income. Currently, the path they tend to follow is first as an assistant to a chainsaw operator (often unpaid) to learn the trade, become skilled enough to be hired by a chainsaw owner to undertake the work on their behalf for millers and tree buyers, to save or borrow money from family to purchase their own chainsaw so becoming an owner-operator or chainsaw owner hiring in operators.

A potential affect on existing millers is the use of chainsaw attachments on their own chainsaws to utilise difficult to access trees, or large trees traditionally halved or quartered for manual extraction to the bench saw. Mobile and static bench sawyers will also come under competitive pressure from chainsaw millers. However, their knowledge network of farmers likely to sell trees, their timber sale yards through which most timber in Meru appears to be sold, combined with their probable lower variable cost per unit output, will potentially mitigate these effects.

For existing chainsaw owners, the 'Alaska' type frame mill is potentially likely to be most popular, as a way to diversify their business from 'chainsaw felling for hire' to 'feller and miller'. In parts of the country where freehand chainsaw milling is common, once the technology is known and buyers offer better prices or demand sized, high quality finish timbers, again uptake of frame mills, even local blacksmith copies, will be high.

The general feeling in Meru amongst stakeholders interviewed is that trees on farms are and have been over-exploited. Millers point to the low availability of trees over 30 cm (12") in diameter, saying they have to travel distances of 20 km or more to find good trees, though they also maybe cheaper there.

The modelled sensitivity analysis suggests that to greatly improve sawmiller returns, more focus should be paid to achieving:

- ❖ the highest recovery rates, (perhaps by not using unskilled and unobserved casual labour) and the
- ❖ the best price for sawn timber (sales and marketing effort along with straight even dimensioned timber)

End users, especially local furniture makers currently using freehand chainsaw milled timber, will benefit through less planing wastage to produce a finished, flat, straight even thickness boards. This wastage reduction has downstream benefits of less timber, fuel, and money per finished piece.

Economic factors

The modelled economic analysis of chainsaw milling has shown good economic performance in Meru, out-competing the prevalent mobile bench saws on most economic performance measures by a factor of two. This means that with their adoption in Meru Central and surrounding districts, as is very likely to happen, there will be increasing pressure on the mobile bench sawmillers. Those who already own the tractor and bench saw trailer combination, who are likely to have already paid off their capital investment, will be constrained to trees within tractor travelling distance.

With the adoption of chainsaw milling attachments, they are likely to expand to areas outside tractor travelling distance as well as competing with bench saws close to Meru. This is likely to introduce the technology to people outside the district who did not witness the training demonstrations

and the technology will spread. Showing that such attachments exist and work well, aided if local blacksmiths or metal workers make more affordable and available versions of the attachments.

Ways forward and policy suggestions

Main stakeholders to take action

- ❖ Government of Kenya (GoK)
- ❖ Kenya Forest Service (KFS) (formerly the Forest Department)
- ❖ Kenya Forestry Research Institute (KEFRI)
- ❖ Ministry of Agriculture (MoA)
- ❖ National Environmental Management Authority (NEMA)
- ❖ World Agroforestry Centre (ICRAF)
- ❖ Forest Action Network (FAN)

Practical and policy changes recommended below were voiced by at least two people interviewed in Kenya, from state, NGO or private backgrounds.

Practical ways forward

1. Make laws regarding trees and tree wood products, enforceable, clear, transparent, widely communicated and sensible for farmers and small scale processors (GoK, NEMA, KFS).
2. Provide information or extension to farmers to allow them to accurately measure the volume and value of a standing tree (MoA, KFS, ICRAF, FAN).
3. Increase farm forestry extension, tree management (tending, pruning), species (genetically diverse), planting (layouts for mutual benefit to agriculture and soil), potential returns over time (MoA, KFS, ICRAF).
4. Encourage more group/community nurseries with good quality native timber tree species, and genetically diverse, high timber quality exotic species (MoA, KFS, ICRAF, FAN).
5. Employ more foresters as trained advisors or extend the training of agricultural extension officers (MoA, KSF).
6. Optimise recovery and timber quality from different mills through research and development (KEFRI, ICRAF).
7. Carry out studies in other areas on chainsaw milling attachments to verify recovery, timing and economics (KEFRI, ICRAF).
8. Develop alternatives to mineral or petroleum- based chain oils, e.g. from oil palm or maize (KEFRI, ICRAF).

Suggested policy changes

1. Reduce import taxes on milling attachments, ripping chains and chain oil, at least temporarily, to promote their uptake and availability (GoK).
2. Harmonise government acts related to land ownership and use, e.g. the Lands Act, Agriculture Act, Water Act (GoK).
3. Reactivate the Forestry Training Centre (KFS, KEFRI).
4. Develop and implement a national chainsaw training course (safety, use and maintenance) for operators (KFS, KEFRI).
5. Develop and implement a chainsaw milling training course, with the involvement of manufacturers and dealers, for timber users (e.g. furniture manufacturers), chainsaw owners, and operators (KFS, KEFRI, FAN, etc.).
6. Clarify the policy on charcoal production, timber and firewood transport and trade (GoK, KFS).
7. Undertake an accurate inventory of standing timber and estimated growth rates, and timber trade between districts as well as internationally (KFS).
8. Record tree felling nationally based on permits issued, to be collected systematically from the District Environmental Committees (NEMA, KSF).
9. Apply pressure on KTDA (Kenyan Tea Development Authority) and BAT (British American Tobacco) to support tree planting, as consumers of ever more trees as fuel for drying (GoK, KFS, FAN).

4 Supporting regional assessments

Introduction to Uganda and eastern DR Congo

For the sake of this study, eastern Democratic Republic of Congo (DR Congo) is treated as part of East Africa. There are very strong social, cultural, economic links and environmental similarities to justify this, in addition to most trading being with its eastern neighbours and virtually all exports passing through these countries as a result of the civil war over the last 10 years.

Studies were conducted in Uganda and the eastern DR Congo to assess the availability, use, economics and efficiency of chainsaw milling, its legal status and impacts on rural livelihoods. Information was obtained by literature reviews, expert interviews, case studies, supporting experiments and observations. Pitsawing, freehand chainsaw milling, chainsaw frame milling and circular saw cutting were assessed, being the most common means of milling in the region.

Legal context for chainsaw milling

Within all countries in the region, there is undoubtedly a discrepancy between what is being legally prescribed and what is taking place on the ground. In addition, laws may not apply to all forest types and contribute more to confusion than to clarification of issues. For example, although Uganda recently reviewed its forest laws, they only apply to forests that are under the control of the state, and two thirds of all forests lie outside the forest law, and owners (private, custodial, communal) can *de facto* do whatever they like with their forests. This is not to say that the law is not enforced, but the myriad of legal settings makes it very difficult for law enforcement agents to create clean cases and the system is very prone to corruption. The illegal user of trees has little problem or requires few funds to declare timber or to get it declared as coming from private land.

In Uganda, the ownership of chainsaws is restricted and the use of chainsaws for further processing of logs is illegal. It was declared illegal to reduce illegal tree felling in state forests, due to their mobility and that they are easy to hide, and chainsaws were for a long time the favourite tool for illegal felling and log conversion in national parks, gazetted forest reserves, but also post-commercial logging areas for 'mopping up' and for cutting and converting solitary trees in farmland. In contrast, the Utilisation Unit of the National Forestry Authority (NFA) is undertaking trials with chainsaw frame mills in Budongo Forest, and according to sources in the NFA, the use of chainsaw frame attachments is now permitted; provided the owner registers with the NFA and pays the due permit fees and royalties. The regulation is applicable for tree cutters operating in state and private forests and on public land. The criteria for permitting a

certain type of chainsaw mill are the evenness and smoothness of the cut and to ensure limited wastage.

In DR Congo, chainsaws are widely used for converting trees into billets and timber. Under the prevailing semi-anarchic conditions, law enforcement is basically non-existent or easily corrupted, i.e. the statement in DR Congo Forest Law that all trees belong to the state is rarely enforced. Chainsaw milling is technically not illegal but should not exist in theory, since only concessioned users are permitted to fell trees for further processing in their own sawmill. For taxation purposes, management of concessions requires pre- and post-felling volume assessments with further monitoring in the log yard of the sawmill, i.e. there is no provision for converting logs in the field.

Who the chainsaw millers are and what they use

Throughout the region, self-employed or contracted tree cutters without access to capital rely on pitsawing with handsaws. In the DR Congo, pitsawing and freehand chainsaw milling dominate, both on farmland and in high forest operations, the latter used if sufficient capital is available. Chainsaws, typically a Stihl 066, may either be owned (rare) or rented. In Uganda, tree millers with legal concessions relied for a long time on portable circular saws (Kara, etc.). In a few cases frame saws (Logosol, etc.) were used. Technology applied in illegal felling and milling differs depending on whether the activity is spontaneous-opportunistic, with the use of very mobile tools like handsaws and chainsaws for freehand milling, or more systematic, with the use of less mobile, more stationary circular and frame saws.

The considered technologies are used in a wide array of situations. In Uganda's forest plantations, small-scale milling technology has a long tradition, both legally and illegally. The plantations typically consist of pine and cypress. There is a close relationship between mobility of tools and legality of activities, with the more mobile tools applied mostly in illegal activities. The same applies for high forest operations. In private woodlots and plantations less sophisticated tools prevail, mainly pitsawing and freehand chainsaw milling, and eucalyptus species dominate. Tools of similar nature are used on farms, in open bush land and on public land.

In Uganda, the local Stihl representative (Stahlco Holdings Ltd.) has two shops in Kampala, one at the Uganda-DR Congo boarder and one in Southern Sudan. For legal reasons they are not allowed to establish themselves in DR Congo as Stihl has an office in Kinshasa, though he is allowed and does operate the shop at the boarder. According to the manager, he has sold very few Stihl frame mills ("about 20 the last 10 years") and equally few Logosol frame mills.

The majority of clients buy chainsaws without any additions, mostly Stihl 066s and to a lesser degree Stihl 088s. Prices and spare parts in Uganda are generally cheaper than in Europe (e.g. 63 cm 3/8 bar US\$90, 90 cm 3/8 bar US\$120; Rapid Super 3/8 chains for 63 cm bar US\$20). Equipment and spares in DR Congo are approximately 75% more expensive than in Uganda and few people can afford it, typically renting Stihl 066 chainsaws at US\$20-25 per day, with a 90-120 cm bar and chain to be provided or rented separately. Examples of prices for chainsaw mills and milling attachments include:

- ❖ Stihl 066 in Kampala, Uganda approx. US\$850, in Beni, DR Congo approx. US\$1250.
- ❖ Stihl 088 in Kampala, Uganda approx. US\$1250, in Beni, DR Congo US\$1800-2000
- ❖ Stihl LSG 450 frame mill (made by Logosol), US\$360, requires Stihl 066 or bigger; 0.325 bar and chain.
- ❖ Stihl LSG 600 frame mill (made by Logosol), US\$520, requires Stihl 088, 90 cm 0.405 bar and chain
- ❖ Logosol frame mill, in Kampala, Uganda, US\$1450, requires Stihl 088; or with electric motor US\$5550.

Products, markets and prices

The principal products derived from chainsaw milling are standard sizes, e.g. 2x4 to 2x12 in. x 7 or 14 ft. lengths in Anglophone Uganda and 7x7 cm, 6x13 cm, 3x30 cm and 3x35 cm x 4.5 m or 6.0 m in Francophone DR Congo. Standard sizes are produced where the market is known and close by. In cases where the markets are far and less known, e.g. in high forest areas of DR Congo, chainsaw millers often prefer to produce billets. In parts of Uganda, where population densities are high and timber scarce (e.g. in the southwest), pit sawyers cut right to the bark (through and through sawing) and attain very high extraction rates.

In contrast, in the context of an ample wood supply in the DR Congo, in rather affluent Beni, near the main functioning sawmill, only fully square pieces can be sold and wastage is accordingly high. On the other hand, in more rural areas with little purchasing power, little or no attention is paid to quality (form, smoothness of cut) and lowest priced products are preferred.

Common to all situations, there is little incentive to utilise smaller diameters or shorter length and species considered inferior or difficult to cut or work (e.g. eucalyptus) since access to forests and large-sized, desirable tree species is basically unrestricted.

During the last four years the timber market in Uganda has seen prices rise 2-3 fold, mostly due to increasing demand whilst supplies are dwindling, but also due to increasingly more successful efforts by the forest authorities to improve revenue collection from forest resources through more open and transparent bidding for concessions and through improved control of remaining resources.

As a result, there is a general tendency to better utilise available trees, e.g. cutting running metres rather than fixed lengths, and to utilise species that were in the past considered undesirable or difficult to work (e.g. eucalyptus, small diameter trees, short stems, etc.). At the same time, lower quality timber including pieces with substantial amounts of bark attached is entering the market since it is more affordable to the poor.

The widening gap between supply and demand has increased illegal activities and imports from neighbouring DR Congo, particularly during recent periods of military activity. Principal boarder entry points are today also major timber markets, mostly for high value hardwoods, usually in the form of billets or as 2x12 in. x 14 ft (5x30 cm x 4.26 m) boards. The principal destinations of timber are the major urban centres, particularly Kampala.

A summary of timber prices can be found in the tables below, and highlight the substantial price difference between Kampala and up-country locations. Timber prices at the main entry point from DR Congo into Uganda, a key market for imported timber into Uganda, could not be verified directly or systematically for security reasons, however, the up-country figures provided below are considered to give a reasonable estimate of prices at the boarder crossing.

The low prices for pilsawn timber reflect the illegal origin of the timber, i.e. they are usually too low to encompass taxes, fees and royalties, etc. Figures for the first three tables are quoted from *The Forester*, a quarterly newsletter published by the Forestry Authority (issue 11, April 2005). Figures usually represent spot checks. US\$1 equals about 1810 UGX (03/01/06).

Table 4.1 Farm gate prices, Beni, DR Congo (Grevillea robusta)

	Size (cm)	US\$ per piece	US\$/ m3
<i>Grevillea</i>	3x35x600	6.00	
	3x30x600	5.00	
	6x13x600	3.25	
	7x7x600	1.75	
	3x35x450	5.00	
	3x30x450	4.00	
	6x13x450	2.50	
	7x7x450	1.00	

Table 4.2 Farm gate prices, Kiboga, Uganda (200 km from Kampala) (Pinus caribea).

	Size (inches" and feet')	UGX/ piece	US\$/ m3
<i>Pinus</i>	8 x 1" x 14'	6,000	155.63
	6 x 2" x 14'	11,000	190.21
	6 x 1" x 14'	5,000	129.69
	4 x 3" x 14'	10,000	172.92
	4 x 2" x 14'	8,000	207.51
	4 x 1" x 14'	4,000	103.75
	3 x 2" x 14'	4,000	138.34
	2 x 2" x 14'	3,000	155.63
	8 x 1" x 13'	5,000	139.52
	6 x 2" x 13'	11,000	204.62
	6 x 1" x 13'	4,000	111.61
	4 x 3" x 13'	6,000	111.61
	4 x 2" x 13'	4,500	125.57
	4 x 1" x 13'	3,500	97.66
	3 x 2" x 13'	3,500	130.22
	2 x 2" x 13'	1,000	55.81

Table 4.3 Kampala market prices (various species).

	Size	UGX/piece	US\$/m3
<i>Pinus</i>	12 x 1" x 14'	20,000	345.84
<i>Pinus</i>	9 x 1" x 14'	15,000	338.33
<i>Cupressus</i>	12 x 1" x 14'	25,000	432.31
<i>Cupressus</i>	9 x 1" x 14'	18,000	405.99
<i>Eucalyptus</i>	4 x 2" x 14'	5,000	129.69
<i>Eucalyptus</i>	6 x 2" x 14'	7,000	121.05
<i>Aningelia.</i>	12 x 2" x 14'	34,000	293.97
<i>Khaya</i>	12 x 2" x 14'	36,000	311.26
<i>Maesopsis</i>	12 x 1" x 14'	10,000	172.92
<i>Blighia</i>	6 x 2" x 14'	6,500	112.40
<i>Blighia</i>	12 x 1" x 14'	10,000	172.92
<i>Celtis</i>	6 x 2" x 14'	6,000	103.75

Table 4.4 Pitsawn and millsawn timber prices in Uganda (after Odokonyero, 2005).

	Sawing method	Local market US\$/m3	Kampala US\$/m3
<i>Khaya</i> etc.*	pitsaw	132.60	309.39
Others**	pitsaw	88.40	209.94
<i>Pinus</i> ***	sawmill	176.80	265.19
-large	sawmill	176.80	265.19
-medium	sawmill	165.75	248.62
-medium	pitsaw	66.30	110.50
-small	pitsaw	44.20	66.30
<i>Eucalyptus</i>	sawmill	165.75	176.80
<i>Eucalyptus</i>	pitsaw	110.50	138.12

* also *Milicia* and other high quality furniture species

** secondary, Lower quality furniture timber

*** also *Cupressus* and other construction timbers

Pitsawing, freehand chainsaw and frame milling, on farm in eastern DR Congo

The context

Forest cover in eastern DR Congo, though rapidly dwindling, is still large when compared to other parts of East Africa. The principal forest type is tropical high forest of the Central African type, with savannah and dryer types today confined to national parks. Land use is characterised by marginal subsistence agriculture. In the past, DR Congo was a major exporter of coffee but with the total decline of the country all but a few large plantations have been abandoned and are either neglected or are squatted by subsistence farmers. Generally, the local economy is weak, and much local trading is conducted through barter. Tree and forest utilisation can be differentiated.

Large scale concession forestry

This is mainly found in the west of the region towards the Congo Basin. A number of companies hold concessions but only two companies are currently active. Many of the concessions obtained during the war are of dubious validity. However, like any other state service in the DR CONGO, forestry concession control and enforcement is subject to omnipresent corruption and accordingly non-functioning. In concession areas, the typical utilisation pattern is that the logging company harvests trees of defined minimum diameter of desirable species. No other operations follow.

Directly afterwards or even in parallel, landless people enter the area and begin to clear the land so as to make way for farming. In other words, even if the concessionaire would want to conduct the legally prescribed post-harvest silvicultural operations this cannot be fulfilled since control over the land is lost. Land clearing is associated with small-scale utilisation of residual trees by local timber cutters, with a focus on high-value species that were not utilised by the concessionaire, i.e. did not fulfil minimum diameters or quality criteria.

The usual technique applied is either pitsawing or freehand chainsaw milling. Pitsawn timber usually consists of billets of 20-30 cm width and height and usually of 4.5–5.0 m long. Billets are sold to local sawmills, often the same ones that left those trees in their concession after the original felling and extraction, delivered to the Ugandan-DR Congo boarder where a thriving timber market exists, or are loaded onto trucks and exported directly to Uganda or beyond. Freehand chainsaw milled timber is also cut into smaller dimensions and sold locally or delivered to the boarder market for export.

Small-scale forest utilisation

This follows either in the path of large scale concession operations (see above) or takes place independently in non-concessioned areas, national parks or on custodial (public)

lands still holding forests. The techniques and approaches applied typically follow the same pattern as for large scale concession forest described above.

Utilisation of trees in farmland and on old estates

Abandoned coffee estates still hold block of trees, often to the extent of 10 hectares or more. The typical species are *Eucalyptus grandis*, *Grevillea robusta* and *Cedrela odorata*. The trees were initially planted for fuel, poles and other construction material. The typical arrangements are boundary plantings and plantations in wet and waterlogged areas (typically *Eucalyptus*).

Utilisation of small plantations rarely takes place. There is simply too much timber of high-value species to be found in nearby forests and there is little incentive to deal with scattered trees. Particularly avoided is *Eucalyptus*. Though some of the trees around the study site are over 50 years old and have reached over 120 cm DBH and 65 m height and are of excellent stem form (up to 35 m clear, utilisable stem length), *Eucalyptus* is considered hard to cut and difficult to work and therefore avoided. *Gevillea* is acceptable but only in certain sizes (4.5-6.0 m roofing material). *Cedrela* is considered a good timber and accepted as a valuable species and taken up if favourable prices are offered.

Utilisation of scattered trees in the landscape follows the pattern and reasons described under above Point 3. There is ample, virtually free wood available and there is little incentive to deal with scattered trees or pay any fees to the owner of a tree. Exceptions include species of particular value (e.g. *Cordia* spp. for its easy to work timber, *Cedrela odorata* for its timber quality) or trees that are suitably located and easy to cut.

Observations were made on three different types of milling operation, pitsawing, freehand chainsaw milling and milling with a frame mill, on an abandoned estate with a timber plantation well stocked with *Eucalyptus* and *Grevillea* (about 10.000 trees in total) of diameters ranging from 30 cm in the smaller *Grevillea* to 120 cm in the largest *Eucalyptus* planted in 1955. The typical *Grevillea* would be about 25-30 m tall, with 4–8 m clear bole. The typical *Eucalyptus* would be 40-55 m tall with 20-35 m clear bole.

Pitsawing

Pitsawing teams usually comprise of 3-5 people, and a local priest and his workers were observed cutting boards from *grevillea* logs, though the crew were poorly motivated, poorly skilled and inefficient. Work on one log was assessed in detail to provide approximate comparative data.

Felling the tree took about one hour, two days to build the scaffold to hold the log, a day to find additional labour to assist in loading the log onto the scaffold, which took nine people three hours. Cutting to standard length (4.5 m long) wasted about 1.0 m of utilisable stem length. Sawing lasted

over a week, with frequent interruptions and times absent. The boards cut were of reasonable quality, and the total value of the 0.71 m³ of sawn timber produced was estimated to be US\$95.40, i.e. 18 boards (2.5x35 cm x 4.5 m) at US\$5.30 each. Overall recover rate from the selected log section (not the whole tree) was 30%. Accurate calculations would require a more detailed study, though in this case was above US\$100/m³.

Freehand chainsaw milling

Both eucalyptus and grevillea (*Grevillea robusta*) were observed being milled freehand (Stihl 066, 90 cm bar). There was no difference in the ease of cutting just felled and old cut grevillea, but there was a marked difference between cutting green and dry eucalyptus logs. A total of 12 trees were measured, resulting in 14 log segments 2.5-6.0 m long, the majority of sections 4.5 m long, with 2.5 m lengths from the top sections of three trees.

A total of 7.82 m³ sawn timber was produced, with an average recovery rate from utilised log sections of 38%, with extremes of 13% from a hollow tree, and 70% from two trees of exceptionally good form cut into 7x7 cm posts, a dimension that gives very high recovery rates. Assuming an average wastage of about 2.0 m log length per tree due to cutting standard lengths, very wasteful cross cutting and very selective choice of log sections, the actual stem section recovery rate is approximately 24%. Timber recovery rate as part of whole tree volume was in the range of around 13%, assuming an average tree height of 30 m and a completely cone-shaped stem.

The output for the three-person team was 0.78 m³/day, with repeated breakdowns due to problems with the worn bar and chains breaking. The chains used had the depth gauges removed, but when a new chain with intact depth gauges was installed the speed of cutting dropped but there was no more chain breakage. On average, the chainsaw would operate for 2.5-3 hours per day, i.e. two thirds of the day the machine was not running.

The average times required for different tasks in relation to the average tree of DBH 68 cm were as follows: 26 minutes for preparing the chainsaw and tree (13%), 29 minutes for cross cutting (14%), 22 minutes for turning the tree (11%), 9 minutes for line drawing (4%), and 117 minutes for sawing and further turning (58%). Thus it takes almost one a half hours before milling can begin, line drawing takes very little time, with milling taking about two hours per tree, or about 6 minutes per cut on average. There was a strong indication that with increasing stem diameters, overall work times and machine hours per m³ of sawn timber fall logarithmically from around 400 minutes per m³ for trees of 20 cm diameter to about 200 minutes per m³ for timber from trees of 80 cm diameter.

Daily consumption of fuel was around 8 l (US\$1.30/l), 2-stroke engine oil 0.5 l (4.00 US\$4/l) and chain lubricant

(waste oil) about 2 l (US\$1.60/l). Total operational costs were thus US\$17.60/day, or on the basis of cubic meters of cut timber, operational costs were US\$22.56/m³. The working crew received US\$0.50 per piece of timber cut. On an average day, 29 pieces were cut, i.e. labour costs amounted to US\$14.50/day or US\$18.59/m³. Including chainsaw depreciation costs (US\$6/day) puts the total cost of production up to US\$48.85/m³ sawn timber if the operator owns his own chainsaw. If local chainsaw rental charges of US\$20-25 per day are applied, this costs of production increase to US\$66.79-73.21/m³, respectively.

Chainsaw milling with a frame mill

Chainsaw milling with a Stihl 066 chainsaw attached to a Stihl LSG 450 frame mill (maximum intake width 43 cm, maximum height intake 27 cm) was monitored cutting ten grevillea and eucalyptus trees, 41-64 cm in diameter and 4.5-27.0 m utilisable log lengths. Regarding to ease of cutting, despite the higher density of eucalyptus there was no great difference between the two species, probably because the eucalyptus was freshly felled. Predictably, with increasing log size the time to prepare a felled tree for milling increased, but decreased in relation to utilisable volume.

For about two thirds of each day the chainsaw did not run, either due to general log preparation works or delays. A four-man team converted about one cubic meter per day from standing tree to stacked timber. However, a team with two chainsaws, one for the preparation of logs and one for frame cutting, working together, could achieve substantially higher labour and machine utilisation rates than two independently working teams, and it was estimated that arranged like this, production rates of 3-4 m³ per day should be possible.

A combined technique of freehand log preparation and frame cutting of boards was used as to square logs with the frame mill was considered too time-consuming. First and second vertical cuts were conducted freehand to reduce log width to fit the frame mill inlet. The first horizontal cut was then made with the help of improvised slabbing rails, and once the first piece was removed and the log had a flat surface the frame was reset and the rest of the log milled. With larger trees, after free hand removal of vertical slabs on either side, further slabs of 7 cm width were removed freehand on either side of the log until the a suitable size was achieved that cut be milled with the frame attachment. The 7 cm slabs were later converted freehand into 7x7 cm posts.

For a given piece of timber (board, post, etc.), cutting times and fuel consumption when frame milling was about one third higher than with freehand milling. With depth gauges lowered it improved, but still remained 15-20% more than when freehand milling. As a rule, local chainsaw operators only cut with the tip of the bar, and with depth gauges removed they expect great chips of wood to be removed, and not relatively fine sawdust as is produced by a normal chain, and operators complained about wasted time and fuel when asked to use an unmodified chain. Then they were

then asked to use a ripping chain with the depth gauges filed off, but this made the chainsaw very difficult to control and the engine would often stall. The most productive chain was found to be a ripping chain with depth gauges reduced by about 0.5 mm.

The surface quality of frame milled timber was remarkable better than freehand milled timber. However, overall quality and log utilisation rates are strongly conditioned by the quality of the first horizontal cut to remove the top slab and to create a working plane. To a lesser degree it is influenced by the quality of vertical cuts, particularly the precision of right angles. Recovery rates from frame milling were high (41-54%) with one exception (34%), and the average recovery was about 20% higher when compared to freehand milling (46% against 38%).

The gains in recovery in free-hand cutting are partly attributable to the large offcuts resulting from preparatory

vertical and horizontal cuts to get a log to a suitable size to be utilised, and a the better utilisation of the remaining block during frame cutting, with it being possible to cut much closer to the bottom of the log. For prevailing tree size, the milling frame inlet of 43 cm with the LSG 450 proved rather limited. Also, strongly tapering trees must be trimmed prior to placing the frame for making the first horizontal cut.

Whether frame cutting is economically justifiable depends on whether the market is willing to pay a premium for quality timber. In the case of the rural neighbourhood market with very little purchasing power, this remains questionable. The local market is highly price conscious and rarely willing to pay a premium for quality, with the best selling pieces being low priced edge pieces with bark attached.

Under given local context, to be economically justifiable, frame cutting is only advisable if conversion rates can be achieved that compensate for higher operational costs per

Table 4.5 Profitability of producing quality chainsaw frame milled timber in DR Congo for sale in Kampala.

Approx. costs using own chainsaw (US\$/m ³)	Cutting 12 x 1" x 14'	Cutting 12 x 2" x 14'
Chainsaw consumables	28.20	22.56
Labour	23.24	18.59
Chainsaw depreciation	6.00	6.00
Costs of production	57.54	47.15
Transport to Kampala (22 m³ timber load)	60.00	60.00
OCC (taxes/ fees DR Congo) @ US\$8/truck	0.36	0.36
Immigration (taxes/ fees DR Congo) @ US\$10/truck	0.45	0.45
OFIDA (taxes/ fees DR Congo) @ 3.3% of value	1.70	1.36
Office of Environment (taxes/ fees DR Congo) @ US\$5/m ³ (bois rouge)	5.00	5.00
Total taxes/ fees DR Congo	7.52	7.18
Import duty (Uganda) @ 7%	8.22	7.50
Withholding tax (Uganda) @ 3%	3.52	3.21
ILC (Uganda) @ 2%	2.35	2.14
VAT (Uganda) @ 17%	19.96	18.22
Fixed fees (Uganda) @ ca. US\$20/truck	0.91	0.91
Total taxes Uganda	34.97	31.98
TOTAL costs/m³	159.92	146.31
Price of Eucalyptus timber in Kampala (US\$/m ³)	160.00	190.00
Profit margin	9%	19%
Price of Grevillea timber in Kampala (US\$/m ³)	190.00	220.00
Profit margin	30%	38%

unit. Comparing derived figures for conversion rates and running costs, it appears that this is marginally possible. The gains of frame milling could be better exploited if a market for quality timber can be established. Such a market exists in Uganda, however, considering transport costs from DR Congo of about US\$60/m³, this sales channel needs to be approached carefully as the following calculation highlights.

In light of these risks, a margin of 40-50% is advisable. Using market prices in Kampala for 12 inch wide and 14 ft long quality 1 inch thick eucalyptus boards, at US\$160/m³ and 2 inch thick at US\$190/m³ the profit is marginal, at 9% and 19%, respectively. *Grevillea*, with prices for equivalent size and quality being US\$190/m³ and US\$220/m³ for 2,inch boards, gives more reasonable profit margins of 30% and 38%, respectively.

The profits can be improved if Ugandan VAT (17%) can be reclaimed and by adopting the usual practice of under-declaring the value of timber at the point of import. Further savings can be achieved if deliveries can be withheld until empty trucks can be found that look for a “backload” to Kampala or beyond. charging lower rates than pre-booked trucks.

Portable sawmilling, in forests in Uganda

Milling plantation pine with mobile circular saws

The Kikonda Forest Reserve (12.000 ha) is leased to an investor for reforestation. The original vegetation consisted mostly of a mixture of *Acacia* spp., *Albizia corearia* and other dry forest trees. A small area contains *Pinus caribea* which is about 35 years old. Initial planting was at 2.7 x 2.7 m, followed by little post-planting care. As a result, diameters are small and wood quality poor. The remaining natural forest has been subject to decades of selective logging, firewood and charcoal making and grazing. As a result, only a few large-sized or well-formed trees remain.

The concessionaire uses contractors with portable circular saws and chainsaws to recover as much of the timber still remaining as possible. Even though illegal, there are chainsaws, usually with 90 cm guide bars, operational around and inside the Forest Reserve. Illegal activities beyond those of the concessionaire are rampant. Chainsaw operators are highly mobile and ‘target orientated’, meaning they identify and cut a tree only if the local market takes it, or a connection to a wholesale business in Kampala is established. The common chainsaw type is a Husqvarna 256.

The legal contractor working for the concessionaire in the pine stands utilises a McQuarry Forestmill 7640, having two circular saw blades. This usually produces standard sized timber independent of log form or length. Due to the small tree diameters found here, two logs were often sawn together. The maximum size that can be sawn is 30x15 cm. A team of 5 people cut and converted 181 logs from 62 trees during

the two weeks of observations, ranging from 7 to 14 feet in length, and from 15 to 50 cm in diameter, with over two thirds of the trees being 20-35 cm diameter.

An overall volume of 47.85 m³ of logs was transported to the sawmill site, and a total of 18.36 m³ of sawn timber was produced, with a mean recovery rate of 40% (35-46%, excluding outliers of 10%, and 91% in one live sawn tree). The average daily output was 1.84 m³ (0.31-3.12 m³/day), being 83 pieces per day (14 to 133), the range resulting from frequent machine breakdowns and subsequent waiting and repairs.

The contractor is paid as follows:

- ❖ Fuel allowance: 100 l per 600 pieces cut irrespective of size (US\$0.18/piece).
- ❖ Maintenance allowance: US\$27.60 per 600 pieces cut (US\$0.046/piece)
- ❖ Management fees and machine rental: US\$276.00 per 600 pieces cut (US\$0.46/piece)
- ❖ Cutting allowance for foreman and 4 workers: UGX240 (US\$0.131) per large long piece, UGX120 (US\$0.066) per large short piece or small pieces, and UGX60 (US\$0.033) for small short pieces.

Based on these figures, the following overall costs can be derived: US\$2.74/m³ labour for cutting and stacking, US\$20.77/m³ for mill rental, US\$8.31/m³ for fuel, and US\$2.02/m³ for mill maintenance, giving a total cost of production of US\$33.90/m³. Other costs for the concessionaire include approximately US\$25/m³ for felling the trees and skidding to the mill and about US\$30/m³ royalties, payable to the forest authorities. The concessionaire sells the timber at an average price of US\$4.156 per piece or US\$187.07/m³, i.e. his gross margin is about US\$98.24/m³.

Limiting factors were transport and having enough available logs close enough to the saw milling site. On one day the fuel for the mill ran out. In terms of earnings for the cutting crew, this translates to US\$0.92/day (UGX 1662/day) for each of the five people in the team, assuming equal pay, and it is doubtful whether this pay alone is sufficient, as experience indicates that the owner of the machine has to pay at least 3-4 times this amount to make pay attractive.

Chainsaw milling in logged-over natural forests

Parallel salvage logging of scattered, left-over, solitary pines and remnant natural forest trees was observed. This allowed the comparison of felling, skidding and sawing costs and to analyse returns from cutting short lengths. Commercial cutting is only allowed with licensed circular saws, but there are outsiders that can be easily employed to extract timber with chainsaws and others that enter the concession illegally and cut timber, especially in the less well supervised areas of this 12,000 ha estate.

The common chainsaw is the Husqvarna 268 (with 60 and

90 cm bars). Remnant *Markhamia lutea* and *Albizia corearia* trees are sought after, with charcoal also produced, and considering the overall shortage of timber and rapidly increasing prices, any tree of reasonable size is utilised. A chainsaw operator was observed cutting a *Albizia corearia* log, 2.15 m long, with 1.12 cm and 0.82 cm base and top diameters, respectively (1.56 m³). A total of 17 pieces of 12x1 in. x 7 ft and 25 pieces of 6x2 in. x 7 ft were cut, resulting in 0.694 m³ of sawn timber, or a recovery rate of 44% from what was a poor quality log.

Two pricing scenarios could be applied, depending on whether the tree owner or the operator provides the chainsaw and fuel. In the first case UGX1500 (US\$0.82) per piece are charged for cutting with the addition of US\$0.13/piece cut for fuel, whereas in the second case the operator charges the owner US\$1.64 per piece cut. The first scenario results in direct operational costs of US\$55,09/m³ (excluding chainsaw depreciation), while the second scenario results in total costs of US\$99.24/m³.

The recent rise of chainsaw milling in northern Tanzania

It is understood that there has been a great increase in the use of chainsaws for conversion of both trees in natural forest trees, plantations and on-farm. To the south of Mt. Kilimanjaro, northern Tanzania, which contains a particularly good mix of agroforestry, natural forests (now all in a national park) and some old private and government plantations, pitsawing which was common until 2004 is now in rapid decline. It is still preferred for milling trees on very steep slopes or in ravines, etc., but the need for raising the log or digging a pit, in addition to the other labour required for conversion, is making it increasingly unpopular.

The main rise in the use of chainsaws for milling in this area is for sawing slabs which are then sold on to sawmills, or for milling small logs and poles with slabbed material used directly in construction. Chainsaw miller move from house to house, smallholding to smallholding, offering their services and products. South Kilimanjaro is economically stagnant at the moment, with low coffee prices a contributing factor, so direct sales of wood are more popular, and timber often forms part of the barter market.

The choice of tree species being milled on south Kilimanjaro is broadening, and this is being mirrored all over the country. Trees such as *Rauwolfia caffra*, formerly planted or retained for its medicinal properties, are now often converted, despite the timber being unfamiliar. Some chainsaw milled timber for sale in a small sawmill and log yard was observed, where most of the wood was *Pinus patula*, *Cupressus lusitanica* and *Grevillea robusta*, the latter popular as a shade tree in coffee plantations, and most was the product of chainsaw conversion. The slabs were of a good standard, requiring no further working for construction use and little planing for

use in joinery or for the manufacture of furniture. In all cases the dimensions were small.

Tanzania still has some fine hardwoods in its extensive miombo woodlands but these are scattered and access is difficult. Also, it was stated that much timber now available in the Tanzanian market was the product of chainsaw milling, and much in rural markets sold as 'local' is coming increasingly from the nearby timber-rich countries of DR Congo and Mozambique. No mention was made of teak, all plantation grown and which is often sold illegally as 'muninga' or other indigenous hardwoods, though this trade attracts financially powerful interests and the involvement of criminality and corruption is likely. In the recent past its exploitation has mainly through sawmills but the superb form of the logs means that rapid chainsaw milling is easy, and although the wear on chainsaw blades is rapid the very high prices for the product, at least US\$300/m³ for logs, should compensate.

Specific conclusions and recommendations

Economics

Pitsawing is the least capital-intensive method for timber cutting and is well suited for conditions where capital is not available or difficult to access or where the cost of renting chainsaws is excessively high. It is also a simple and robust technology and adapted to situations where machine operation skills are lacking. It creates more local employment per cubic metre than any of the other technologies. However, in the case observed, it proved to be rather costly per cubic metre and it still required certain skills to attain satisfactory quality, especially in avoiding tapering boards. The transfer of logs onto the scaffold is also highly dangerous, and larger logs would require the digging of pits under the tree, reducing the risk of accidents but increasing costs.

Freehand chainsaw milling is more capital demanding than pitsawing and is surely the most dangerous way of cutting timber, especially since most chains have depth gauges removed. Technical skills are demanding, i.e. it requires skilled operators to attain satisfactory quality, especially to avoid tapering boards and scarred and rough surfaces. The method also requires a good amount of entrepreneurial skills to ensure profitable operations. The impact on employment is limited and is less than in pitsawing.

Chainsaw frame milling is the most capital demanding of these three observed techniques. Taking into account the costs of a typical chainsaw (Stihl 066, ca. US\$850), the addition of a 43 cm frame (Stihl LSG 450) adds less than 50% (US\$360).

Compared to freehand milling, health and safety risks are lower, as the chainsaw is held on both sides, and because

the largest part of the chain is covered or in the wood during operations. Frame cutting gives much higher conversion rates, due to boards with a consistent thickness and good surface finish, maximisation of utilisable log width at any point of the tree resulting in the widest possible boards; and smaller off-cut wastage resulting in more boards and side slabs with one smooth surface that can also be sold. The quality of the timber is also markedly better than in any of the other two techniques applied (no taper, smooth surface, clean 90 degree angles). In combination with freehand preparation of logs for frame slicing (vertical cuts to square logs) it is nearly as fast as freehand chainsaw milling and permits higher per hour and unit output.

The combined effect of better quality, higher conversion rates and lower unit costs makes it the most attractive technique. However, whether this can materialise is strongly determined by the willingness of the market to pay a premium for better quality. In the described case this depends on species and chosen timber sizes.

Security, ergonomics, maintenance

Both in Uganda and the DR Congo, there is little active precaution for safety and ergonomics when operating chainsaws or small sawmills. Personal protective equipment is usually completely absent and handling of chainsaws and body posture during working are extremely tiresome. In freehand milling, usually only the tip of the chainsaw bar is used, with all the associated risks, and removing the depth gauges from chains so as to cut more rapidly further aggravates the situation.

For making longitudinal cuts, operators consider it helpful to use long bars, facilitating straighter cutting. The typical bar length is 90 cm for economical reasons, as whereas the preferred length is 120 cm, these are expensive (ca. US\$120 in Uganda). Cases were observed were two bars of 90 cm were welded together in a crude fashion locally so as to obtain the desired length.

Chainsaw operators usually acquire their skills from working with a logging gang where they gradually become acquainted with the machines. None of the interviewed workers had any formal training on operating chainsaws. The lack of training partly explains the poor handling of chainsaws and the high risks taken during operation. The problem is aggravated by working with blunt chains, and using the tip of the bar is considered a way to overcome this, and by removing depth gauges to accelerate cutting.

Maintenance of equipment is usually poor and chain oil (engine waste oil) causes excessive wear on bar, chain and oil pumps and spoils the appearance of the timber. Alternative lubricants (e.g. local palm oil) would be cheaper and most likely less damaging to equipment. In this sense, there is a tremendous need for training.

General evaluation and impact assessment

It would be dangerous to draw definitive conclusions from these few observations, and also since availability and access to trees and capital and the general socio-economic context determine the most appropriate technology or course of action. From an economic point of view, if capital is not a limiting factor, operators should move to frame milling (or even circular saw mills).

Compared to pitsawing and freehand milling, the use of frame mills increases overall recovery rates, output per working hour, the quality of the timber produced, while decreasing the overall costs per cubic metre of timber sawn. Similarly, frame milling is safer and more ergonomic than pitsawing or freehand chainsaw cutting. However, it also requires more skill and an advanced degree of professionalism in operating a chainsaw and managing a work team, and to be successful a clear understanding of markets is required to materialise the benefits derived from better quality products. In contrast, if capital is limited, pitsawing may be the only option, even though it results in lower recover rates, higher per unit costs and is at the expense of safety and ergonomics.

The more limited the resource the more feasible will be investments in frame milling equipment that permit higher timber recovery rates and reduce per unit costs. Frame mills are also advantageous, as compared to the other two techniques, they permit the cutting of smaller diameter trees with reasonable recovery rates.

Overall, there is little case for freehand chainsaw milling. It can neither compete with the low capital demand associated with pitsawing nor can it deliver the quality, cost-efficiency or extraction rates associated with frame milling. This is not contradicting the experience from Uganda that freehand chainsaw milling of eucalyptus results in higher recovery rates than circular saws, mostly because the operator is more flexible in deciding which sizes to cut from a given log section. Applied to the same situation, it is a fair assumption that frame milling will be equally flexible but will additionally increase recovery rates.

The argument that chainsaw milling can add to on-farm income cannot be maintained from the observations in DR Congo, at least from the perspective of the tree owner. In forests and national parks there is simply too much high-value timber easily accessible, and as a result, timber cutters prefer to utilise that virtually free resource of large diameter trees that require only a few chainsaw operation hours per unit volume and high per unit input returns. Local timber prices are low and there is very little incentive to cut anything else than the best, and ignoring less valuable species or small tree sizes.

The biggest beneficiaries of chainsaw milling in DR Congo are the owners of the chainsaws that are rented out. Daily rental charges are three to four times higher than estimated depreciation costs. Both in Uganda and DR Congo, chainsaw

milling undeniably contributes to rural livelihoods, however, in most cases in an illegal context, raising questions with regards to the appropriateness of prevailing policies and laws.

Policy and law

Except in DR Congo, there is no doubt that timber demand and supply show an increasingly widening gap. It would be wrong to look the other way and permit uncontrolled utilisation of chainsaw equipment because it may help to utilise timber resources better. However, it also remains doubtful whether the all-out ban on chainsaw milling should be maintained.

Chainsaw milling and chainsaw milling attachments can contribute to improved utilisation of scattered trees and trees on farmland. They provide income and a local supply of affordable timber to local communities and add value to trees and thus make them or new plantings more valuable to owners. However, in light of past experience, policy makers and forest services are well advised to act prudently on this subject. Mobile equipment is and was an important element of illegal timber utilisation.

Some progress in this sense has been made. In Uganda, the long-standing ban of chainsaw-based cutting systems has recently been reviewed. Though freehand chainsaw cutting is still prohibited, frame mills and carriage mills can now be licensed by the authorities and there are calls to lift the chainsaw logging ban altogether. However, a possibly better way would be to first register the machines and then to license operations. This could be done at the point of import since very few companies manufacture or deal in such equipment.

Licensing of operators could be conditioned on attending training and/or passing an exam, and then to licence the equipment to the trained owner/operator. Licensing and training can be conducted at local, forest district level. In addition, training reduces accident rates, contributes to quality and extraction rate improvements and increases the lifespan of equipment. In summary, training is highly desirable, if not essential, economically feasible and a tool to direct licensing. Licensing further helps to make licensed machines and licence holders known in the local community and helps to gain a certain control over activities in private or communal forests.

In the case of DR Congo, law enforcement is basically absent, or corruption is omnipresent, and it would be academic to give a recommendation on the subject. With regards to environmental impacts, the underlying causes of deforestation or environmental degradation that may be associated with tree cutting and timber making are not so much a question of technology but of law, policy and the willingness and ability to enforce of law. This is definitely the case in the DR Congo and often in Uganda.

Summary recommendations

Under the given context, increased recovery rates stands against increased capital intensity of machinery. It appears questionable whether freehand chainsaw milling is an appropriate method, both economically or environmentally. On the other hand, per unit output costs for frame milling were considerably higher in the single situation observed.

When cutting single trees, a combination of freehand preparatory cutting of trees into squared logs followed by frame milling of boards proved the most promising technique. In the case of systematic pine cutting, semi-stationary circular sawmills are most appropriate. Applied research should focus on optimising cutting techniques so as to increase utilisation rates, taking into account tree diameter, log length, timber value and proximity of markets.

Training is also required, in general chainsaw safety, use and maintenance, the use of chainsaw milling attachments, also sawing techniques, drying and marketing.

Introducing a licensing system could reduce the risk of illegal cutting associated with highly mobile milling equipment. This appears feasible since very few companies import such equipment. Further studies should be initiated to define an appropriate policy framework, including stakeholder consultation on possible mechanisms of licensing and controls, so as to develop applicable policies with regards to mobile saw milling equipment utilisation. Key players in this will be international manufacturers and importers and distributors of such equipment.

5 When chainsaw milling is sustainable and appropriate

Multi Criteria Analysis on chainsaw milling in East Africa

Introduction

This section presents a decision support tool assessing policy options regarding chainsaw milling in East Africa, based on results from the case studies, particularly that of Meru, Kenya. Though restricted in its scope, it suggests that a policy of ‘Promoting farm timber and Processing’ could be exceedingly beneficial and without question the preferred choice of those options presented. This report takes the reader through the process of Multi Criteria Analysis (MCA) or Multi Criteria Decision Analysis (MCDA) techniques examining potential policy options to “...enable national forest administrations to determine the conditions under which chainsaw milling is appropriate and sustainable”. Costs and financial benefits associated with the policy options is usual in MCA or MCDA were not, however, assessed in this analysis. Rather, due to time and financial constraints, an assessment has been made of three potential policy options against a set of criteria derived from conditions and policy drivers in East Africa. These policy options have then been scored for their performance on the criteria. To account for the different importance and scope between criteria, two techniques of MCA have been applied, relative difference scoring and swing weighting. This report is accompanied by a downloadable spreadsheet to allow policy makers and others to explore the process and input their own criteria scores and weighting factors against options that they can also change.

This study follows on from a data collection framework tool (see Chapter 3) assessing the economic performance of chainsaw frame mills versus current tractor driven circular bench saws within the social, policy, and environmental context in Meru Kenya. This analysis then utilises information from the data collection framework and literature review.

Usually studies of MCA or MCDA gather stakeholders and/or decision makers together to form the policy options to be studied, the criteria against which the policy options will be judged and the relative importance or weighting of the various criteria in assessing the policy options. It normally utilises criteria on which information on revenue benefits and costs can be collated, collected or is known, as well as non-economic assessments for criteria which cannot be judged by costs and revenue benefits. A full account in the Multi-Criteria Analysis Manual, used by UK government departments and employed in this study is available. The purpose of applying MCA or MCDA methodology is to compare and assess, in a clear and transparent way, the process of arriving at a decision when faced with competing

and difficult to compare factors, rather than relying on one view or ‘gut feeling’ of what is the right judgement.

This chapter is not attempting to describe or act as a manual on MCA or MCDA, simply to use these methodologies to provide a Decision Support tool. Readers wishing to know more about this type of analysis or are unclear how it is applied are advised to read the references included.

Policy options

Two policy options were fairly obvious, the first, ‘do nothing’ common to all types of MCA and MCDA as a control, allowing overall judgement on merits or costs of other policy options to be compared to it. The second, of ‘restricting chainsaws’ was clear due to the restrictions on chainsaws in Uganda and its consideration as a way to reduce illegal felling elsewhere, therefore a logical policy option. Deciding on, and justifying, policy options is often problematic, due to conflicting views of those formulating the options or ensuring they are feasible. Though the purpose of this work was to examine chainsaw milling, the dependency seen in Kenya on supplies of sawn timber from farmers with farmer and sawmiller interdependency, demonstrated that a simple policy option of ‘encourage small scale milling’ would be mistaken. To account for the dependency, to be more holistic and with the knowledge of the widespread network of agricultural extension officers in Kenya, the option of ‘promote farm timber and processing’ was decided on, as this seemed to offer a good range of policy options.

Deciding criteria for assessing policy options

The criteria were decided on by looking at the mission statements or aims of the Kenyan National Environment Management Authority (NEMA) “To promote, safeguard and enhance the quality of the environment”, the Kenyan Forest Service (currently being formed, formerly the Forest Department), using the purpose of the 2005 Forests Act “Management, utilisation and conservation of all types of forest”, and the UK government’s DFID mission statement “Leading the British government’s fight against world poverty”. In addition, experience in Kenya promoted additional criteria attempting to reflect the perceived drivers of farmers and sawmillers. A value tree for the criteria is shown in Figure 5.1. It could also be drawn as a Venn diagram as parts overlap.

In deciding on the criteria to use to assess the policy options, a list was first drawn up of all the various benefits and costs associated with chainsaw attachment milling and the three options. However, of the sixty or so, many were of minor or incidental importance, for example ‘greenhouse gases’ when compared to others such as ‘poverty reduction’. There was

Figure 5.1. Value tree of criteria

Sustainable development	Environment	Increase of (farm) floral and faunal density, diversity and cohesion and exotic gene diversity Decrease of public forest destruction / illegal felling Decrease of farm soil erosion and improved water quality and supply Afforestation (farm)
	Poverty	Poverty alleviation / pro-poor growth Community involvement, Participation and Decentralisation Fuel wood (firewood and charcoal) from farms Agricultural crop / animal productivity Farmer income diversity (including non-cash savings) from trees
	Business	Small timber business development and opportunity Recovery / efficiency log to sawn timber Law / regulation enforcement National economy

also double counting of criteria that is two essentially meaning one thing, such as ‘greenhouse gases’ and CO2 emissions’, both of which could be seen as part of the criteria ‘Afforestation’. Eventually through examination, this list was reduced to thirteen criteria, some of which are compound criteria such as ‘community involvement, participation and decentralisation’. Figure 5.1 shows the final list which was then assessed against the options decided upon. Table 5.1 shows the scoring for criteria and the reasons for this scoring.

Scoring the performance of options against the criteria

The next stage is to allocate to each criteria, a performance score to each option. The reasoning for allocating the performance score is noted beside the scores and is an essential part of the transparency process as well as a check on the size of the allocated performance score.

A number of references from the Multi-Criteria Analysis Manual indicate that these scores should be assessed for their relative differences. The most preferred option is assigned a preference score of 100, and the least preferred a score of 0. Scores are assigned to the remaining options so that differences in the numbers represent differences in strength of preference. What do these preference scores represent? The difference-scaling method results in numbers that represent relative strength of preference. Such a measure expresses the value associated with the option’s consequence on a particular criterion. The phrase ‘strength of preference’ is here used instead of ‘value’, because the latter is often implies only financial value. However, ‘strength of preference’ should not be confused with ‘preference.’ In decision theory, preference implies two measurable quantities; probabilities and utilities. Thus, A could be preferred to B even if they are equal in value because A is more likely to happen. If strength of preference is to be taken only as a measure of value, then A and B must be assumed to be equally likely. To judge how different the option scores are to one another for the same criteria, several other methods can also used. To allow for the relative differences

between the scoring of options involves allocating a zero score to the lowest performing option for a criteria, and a maximum 100 to the highest performing option score for a criteria. For those options in between, a score is calculated proportional to the difference between the highest scoring and the lowest. This method explicitly therefore highlights relative performance or preference.

The spreadsheet that accompanies this report allows for user input of ‘raw’ scores and automatically calculates relative difference scores.

Weighting importance of criteria

As not all criteria have equal importance, it is necessary to increase the scores of criteria that are more important and reduce the scores of those criteria that are not so important. This is usually referred to as weighting. Weighting is also best carried out by stakeholders and or decision makers to utilise their insight and understanding of the issues, the interrelationships and externalities. However, this was not possible in this study due to budgetary and time constraints. To try to give some perspective, the author, John Samuel, therefore has guessed the potential weightings of four different groups: The environmental service (NEMA), forest authority (Kenya Forest Service), DFID, and rural people.

Criteria are then weighted by a number proportional to its importance seen by each of the groups. For example, rural people may weight the importance of ‘poverty alleviation’ as highest priority and ‘decrease in forest destruction’ one of the lowest, whereas the government forest authority may weight ‘decrease in forest destruction’ the highest and ‘agricultural productivity’ as the lowest. The weights from each of these groups are then combined for each criterion, to form a combined weight. This overall weight can then be applied to the scoring of the criteria against the options.

Table 5.1. Decision support tool for East Africa, utilising experience and information from Meru Kenya, presenting a medium to long term assessment (5 to 20 years) of policy options regarding chainsaw use, indicating raw scoring for criteria and the reasoning for this scoring.

Criteria	Do nothing	Promote farm timber & processing	Restrict chainsaws
Scores out of 100 on how the policy will effect the criteria			
Increase floral and faunal density, diversity, cohesion on farm	65 Focus is on farms likely to be short term, what their neighbours do and ideas of what timber buyers want in the area. This may lead to loss of lesser importance non-timber tree species, more monoculture of the cheapest locally raised exotic tree seedlings	90 Extension services armed with knowledge of farmer 'drivers' (growth rate versus timber tree value or subsidiary purpose to sawn timber) and access to good diverse subsidised seedlings likely to increase this criteria	60 The long term focus of farmers is likely to shift toward agricultural subsistence and cash crops, reducing tree cover of all species, though small trees for firewood may increase.
Decrease of public forest destruction / illegal felling	60 In areas with sawmills or access to, due to the demand for sawn timber and declining farm supply of trees, potential for increased illegal logging	70 Promotion and tree planting has potential to take pressure off natural public forest, though 'man transportable' chainsaw attachment mills would be a tempting tool of choice for those deliberately targeting public forests a distance from habitation.	80 In areas with forest adjacent communities who report incidents, chainsaws not generally used. Would those carrying out illegal activities not by-pass chainsaw restrictions? Perhaps not as easily.
Reduce soil erosion, improve water quality and supply on farms	70 Little account taken of erosion in planting design or placement of trees, farmers concentrating tree planting on farm or field boundaries.	80 Extension services tailored to farmer needs likely to decrease erosion and increase water quality	60 If focus is likely to shift toward agricultural subsistence and cash crops, reducing tree cover of all species, then erosion will increase and so water quality will decrease.
Afforestation on farm	60 In areas with sawmills declining age structure but maybe more tree planting due to demand, sawmillers re-locate or travel further to buy trees of a suitable size.	80 Likely to increase afforestation due to demand and recognition from extension services of the contribution trees can make to income. Potential increased carbon sequestration and reduced greenhouse gas output.	40 Potential long term decline of tree planting in favour of agriculture due of timber tree harvesting difficulties. Decreased carbon sequestration and increased green house gas emission.
Poverty alleviation / pro-poor growth	70 Some benefits in areas with existing mobile bench saws for landless and young semi/un-employed through employment (usually less than US \$1 per day) as well as small farmers selling their trees (often at poor prices). Slow spread of chainsaw frame mill technology bringing potentially better benefits in the long term.	90 Access to finance at fair rates, liberalisation of banking sector, combined with general business training courses and extension work (well informed and promoted sawn timber [including chainsaw milling using attachments] and farm timber sector), likely to be vibrant and well performing economically, providing good employment and business start-up (with low capital costs) opportunities, as well as better prices for small farmers selling single trees. For farmers, chainsaw mills, especially in areas remote from current sawmills, may make a large difference in income, as they may now be able to sell their trees, and increase income security. Equally, this may encourage more tree planting so adding to livelihood protection.	55 Fuel wood (whether legal or not) sales and work will still provide some income and employment though likely at much reduced levels than other options.

Table 5.1 continued

Criteria	Do nothing	Promote farm timber & processing	Restrict chainsaws
Scores out of 100 on how the policy will effect the criteria			
Community involvement, participation and decentralisation	<p style="text-align: center;">40</p> <p>The well informed or connected can take advantage of situations where information and assistance is not easily or clearly available. Wealth of 'on the ground' evidence of the need for assistance to the community to make informed, appropriate and fair decisions. In areas of common land or trust ownership (for example in semi-arid nomadic grazing areas) this will be particularly important (especially in exotic shrub infested areas).</p>	<p style="text-align: center;">60</p> <p>Assistance (for example under the Kenyan 2005 Forest Act) for small sawmillers to combine with community groups for management of gazetted forest areas including timber plantations. Two further opportunities; (1) community groups purchase and operate chainsaw mills for the benefit of the group; (2) community groups employ chainsaw millers to mill the group's trees for them. Providing information and extension services could empower local people to make use of their resources creating income.</p>	<p style="text-align: center;">30</p> <p>Due to restrictions, community groups and their decisions on forest resources likely to be restricted to non-timber forest products and fuel wood. Few or no benefits of timber production filtering to local economy or community, fewer potential jobs. Semi-arid pastoral areas with infestation of exotic shrubs will face further problems of spread and reduced grazing, with little opportunity for conversion to timber or charcoal.</p>
Fuel wood (firewood and charcoal) from farms	<p style="text-align: center;">65</p> <p>With unclear, variably enforced, poorly communicated laws and regulations for all timber products (despite fuel wood being the largest energy source with an estimated 24 M m³/yr used in Kenya), trade in wood products is constrained, so also tree planting, tending, along with increased fossil fuel imports and environmental costs.</p>	<p style="text-align: center;">80</p> <p>With promotion at all levels of government, (so clear, unambiguous and communicated laws and regulations favouring farm timber) tree planting and products, including fuelwood, may well be increased and so locally produced sustainable energy sources</p>	<p style="text-align: center;">50</p> <p>Cost of fuelwood may rise due to increased labour, potential long term decline of tree planting in favour of agriculture because of timber tree harvesting difficulties and costs. Industrial fuelwood users, such as KTDA in Kenya, likely to need to look to other sources or technologies.</p>
Agricultural crop / animal productivity	<p style="text-align: center;">70</p> <p>In Meru Kenya for instance, mutual benefits of agriculture and timber tree growth is recognised and utilised</p>	<p style="text-align: center;">75</p> <p>Well informed, tailored extension can increase agricultural and tree production though the mutual benefit that can accrue with good agroforestry design.</p>	<p style="text-align: center;">85</p> <p>Increase in productivity, if focus is likely to shift to agricultural and away from trees in some argi-ecological zones, though long term problems may ensue from erosion and lack of nutrient cycling.</p>
Farmer income diversity (including non-cash savings) from trees	<p style="text-align: center;">55</p> <p>With no information on tree pricing, farmers face poor and unfair tree prices exacerbated with unclear, variably enforced, poorly communicated laws and regulations for all timber products</p>	<p style="text-align: center;">65</p> <p>With communication and extension work on tree prices, sawn timber prices and tree volume measurement, farmers are likely to achieve good prices for timber trees adding to their non-cash savings for hard times (or occasional cash needs e.g. school costs). The contribution to farmer income from trees with good information could rise by 50% from the evidence seen in Meru, Kenya. However, the overall contribution by tree sales to farmer incomes is still seen as relatively small as compared to agriculture.</p>	<p style="text-align: center;">40</p> <p>Little opportunity for non-agricultural income diversity because of constrained sawn timber sector.</p>
Small timber business development and opportunity	<p style="text-align: center;">60</p> <p>Chainsaws frame mills, (modelled as economically out-competing mobile benchesaws) will spread slowly relying on word of mouth or business expansion. With no training, accidents and deaths will continue and increase with spread to areas currently without small sawmills, whilst the removal of depth gauges on chains will cause increased long term medical incapacity of operators due to vibration. Without some business skills support, some new chainsaw frame milling businesses may fail due to poor resources and market planning.</p>	<p style="text-align: center;">100</p> <p>With business skills, operating and safety training, the small sawmilling sector could thrive (in Kenya potentially supplying all the countries sawn timber needs), given parallel support for farm timber. Given the modelled good economic performance of chainsaw frame mills, many small businesses using local timber for local needs, are likely to be set up, including in areas without current sawmills due to the relatively small capital costs. Studies have shown, in Europe and N. America, there are few economies of scale in sawmilling.</p>	<p style="text-align: center;">10</p> <p>With restrictions, costs for fixed and mobile bench sawyers will rise, the relatively poor economic performance will be further hampered and the sector stagnates or decline with loss of jobs and local finances. Consequences include more imported timber, probably from illegal harvesting in the moist African tropics.</p>

Table 5.1 continued

Criteria	Do nothing	Promote farm timber & processing	Restrict chainsaws
Scores out of 100 on how the policy will effect the criteria			
Recovery / efficiency log to sawn timber	70 Current conversion efficiencies with free hand chainsaw milling especially and many mobile benchesaws is often poor. Free-hand chainsaw particularly produces uneven sized boards which need further processing and so waste. This wastes resources, depresses prices for farm trees and leads to more trees being felled to produce the same amount of timber.	90 With training and promotion of chainsaw frame mills, recovery is as good and can be better than mobile bench saws, at lower cost, better safety, and the opportunity to utilise more portions of the tree. Small percentage increases in efficiency make very large differences in sawn timber output on a regional or national scale.	40 Reversion to pitsaws or continuing use of mobile bench saws will maintain poorer recovery of timber. Felling with hand tools is very wasteful of timber because trees cannot be cut close to the ground.
Law / regulation enforcement	60 Continuing semi-disregard for unclear, variably enforced, poorly communicated laws and regulations for all timber products, leading to opportunities for official bribery or favours, depressed business opportunities and farmer tree prices and planting. Little opportunity to distinguish between legally and illegally sourced timber or wish to do so. At least three ways corruption could interact; (1) bribes are made to gain access to trees, (2) a culture of bribery excludes certain groups or people potentially undertaking a business, (3) 'knowledge brokers' work against the interests of farmers by not giving advice (its 'not their place' to do so), giving poor advice or by introducing or telling only certain millers.	80 With promotion at all levels of government, and so clear, unambiguous and communicated laws and regulations favouring farm timber, it is more likely legal behaviour will occur with respect and consultation, rather than disregard, for government agencies relating to timber and trees. Opportunity to allow distinction of illegal timber such as through audit trails from permission of tree felling is presented with this option.	30 Likely disregard of restrictions (such as in Uganda), increased opportunities for bribery of officials general sense that small scale timber industry is illegal / unsanctioned, potential from more illegal felling of native trees on farms without their replacement.
National economy	60 Chainsaws frame sawmills, (modelled as economically out-competing mobile benchesaws) will spread slowly, relying on word of mouth or business expansion providing some national benefits. Low level promotion of trees on farms will cause potential long term problems of lack of supply and so more imports.	75 Better balance of trade. Promotion of farm trees and chainsaw frame mills could make a considerable contribution to import substitution from neighbouring countries or by ship. Their improvement in recovery rates over free hand chainsaw milling will also make a considerable difference. Increased employment opportunities and farm incomes may assist regional economies and reduce 'flight to the cities'.	10 Decrease of potential national benefits, even if chainsaws were taxed to gain some revenue. If chainsaws banned, potential strong decrease in National Economy especially from fuel wood substitution with fossil fuels.

The spreadsheet that accompanies this report allows for user input of 'raw' weights of any number to each criterion and then automatically harmonises these weights to each criteria so they total 100 for all the criteria in later calculations.

Proponents of MCA / MCDA recommend a process called 'swing' weighting. This is based, once again, on comparisons of differences: how does the swing from 0 to 100 on one preference scale compare to the 0 to 100 swing on another scale? To make these comparisons, assessors are encouraged to take into account both the difference between the least and most preferred options, and how much they care about that difference. There is a crucial difference between measured performance and the value of that performance in a specific context. Improvements in performance may be real but not necessarily useful or much valued: an increment

of additional performance may not contribute a corresponding increment in added value. Thus, the weight on a criterion reflects both the range of difference of the options, and how much that difference matters.

Swing weighting accounts for both the range of differences of the options and how much that difference matters. It again utilises the difference between performance scores against the options, starting from the criteria with the biggest swing (difference) from one option to another. The process used in this study swings all the other criteria against the largest, reducing weightings by a percentage equal to the amount less the criteria's swing is compared to the largest. Therefore, if the largest swing is 50 points (highest option score 90 lowest option score 40) and criteria X had a swing of just 25 points then the weight on criteria X would be reduced by 50%. The

Table 5.2 Estimated allocation of importance scores (weights) to criteria by various bodies

Criteria	Government environmental service	Government forest service	DFID (UK)	Rural people
Increase of (farm) floral and faunal density, diversity and cohesion and exotic gene diversity	22	8	15	2
Decrease of public forest destruction / illegal felling	22	25	15	2
Decrease of farm, soil erosion and improved, water quality and supply	15	4	10	8
Afforestation (farm)	10	16	6	2
Poverty alleviation / pro-poor growth	8	4	25	30
Community involvement / participation / decentralisation	6	8	20	10
Fuel wood (firewood and charcoal) from farms	4	8	6	15
Agricultural crop / animal productivity	3	2	6	25
Farmer income diversity (including non-cash savings)	2	2	15	10
Small timber business development and opportunity	1	6	8	5
Recovery / efficiency log to sawn timber	1	8	2	5
Law / regulation enforcement	18	20	2	8
National economy	2	4	12	0

relative difference score is multiplied by the swing weighting to produce the results. Table 5.2 shows the weighting the author applied on behalf of the potential contributors to policy making decision

Policy option performance results

By cumulatively adding the 'swing' weighted relative difference scores on the options, the results of the analysis (Figure 5.2), show that 'promoting farm timber and processing' is clearly the preferred policy option in this assessment. Using this methodology the other policy option of 'Do nothing' is a very poor second, cumulating half the weighted score of 'promoting farm timber and processing', whereas 'Restricting chainsaws' hardly registers as a policy option and so can be rejected easily. By using a cumulative graph to display the results, the contribution of each criteria can be seen. The biggest criteria contributors in order are 'Law / Regulation enforcement', 'Poverty alleviation / Pro-poor growth' and 'Small timber Business development and opportunity' to the policy option 'promoting farm timber and processing'.

To aid clarity of the process of relative difference and swing weighting, four sets of results are presented in figure 5.3. The raw weighted scores shows the result of just applying the summed weighting to criteria scores, without carrying out the relative difference or swing weighting process. As a result the policy options are much closer together in cumulative score because no account has been taken of the importance of one criteria compared to another. Clearly applying the relative difference process alters the scores to

the greatest amount. If more than three policy options were presented, the effect of the relative difference process is likely to be less strong. All subsequent presentation of the results will only refer to swing weighted relative difference scores.

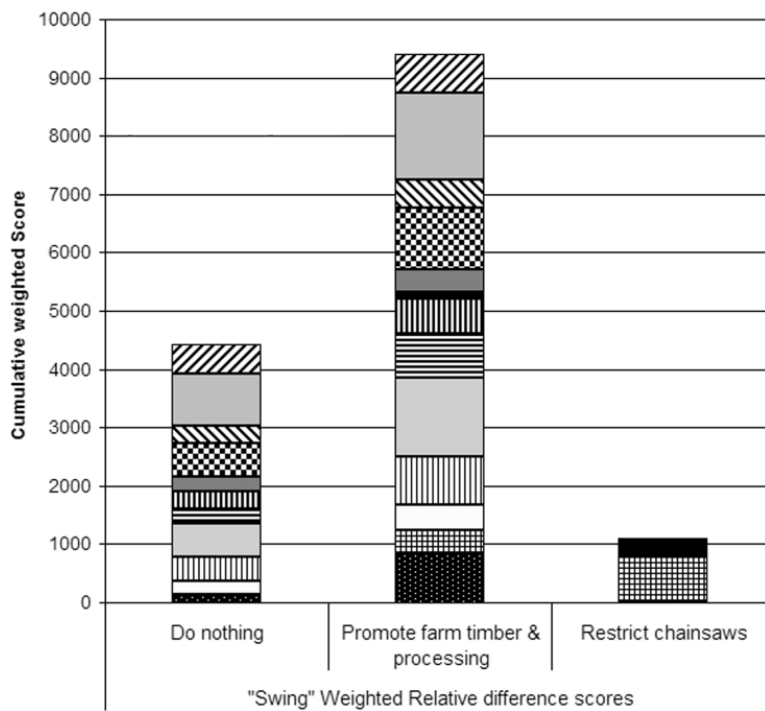
Sensitivity testing results

To ensure that the process of giving performance scores to criteria and ascribing importance or weighting to the criteria give a true picture of the results, sensitivity testing is used. Essentially this sequentially increases or decreases the option scores, weightings and criteria score to see if the policy option scoring the highest still does so. Sensitivity helps to judge if the results give a fair assessment of the ranking of policy options. As with most MCA or MCDA studies, the results are fairly insensitive to even large changes in performance scores or importance ratings.

Option score sensitivity

Figure 5.4 shows the sensitivity of the options to changes of option scoring. 'Promote farm timber and processing' is still the most favoured policy option whether the 'do nothing' or 'restrict chainsaws' options have their scores increased by 20%, or it has its score decreased by 20%. Interestingly, if the 'restrict chainsaw' option is boosted by 20% this decreases the 'do nothing score' as it receives more of the second place criteria scores. The MCA model that accompanies this report, allows users to input various sensitivity figures. With the current criteria and weighting scores, 'promoting farm timber and processing' only becomes the second choice

Figure 5.2 Policy results from the MCA method



Key to figures 5.2 - 5.6

- National economy
- Law / Regulation enforcement
- Recovery / efficiency log to sawn timber
- Small timber Business development and opportunity
- Farmer Income diversity (including non-cash savings)
- Agricultural crop / animal productivity
- Fuel wood (Firewood and Charcoal) from farms
- Community involvement, Participation and Decentralisation
- Poverty alleviation / Pro-poor growth
- Afforestation (farm)
- Decrease of farm Soil erosion and improved Water quality and supply
- Decrease of public forest destruction / illegal felling
- Increase of (farm) Flora and Fauna density, diversity and cohesion

Figure 5.3 Comparison of the results of different MCA methods

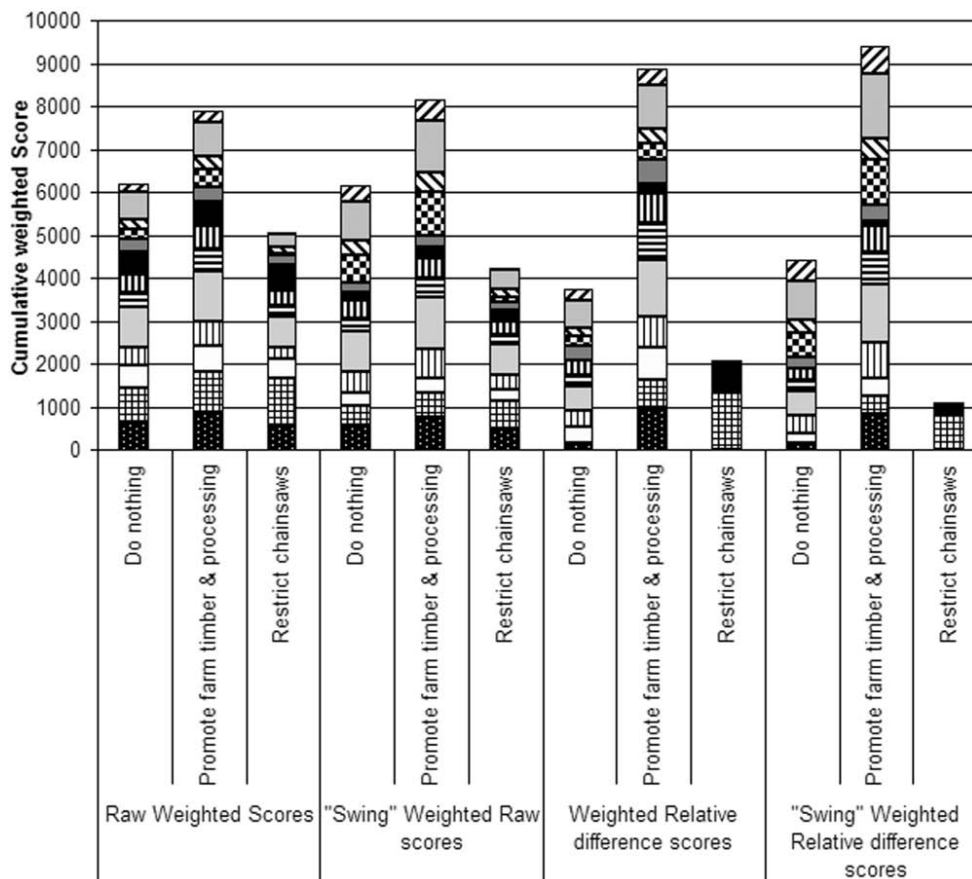
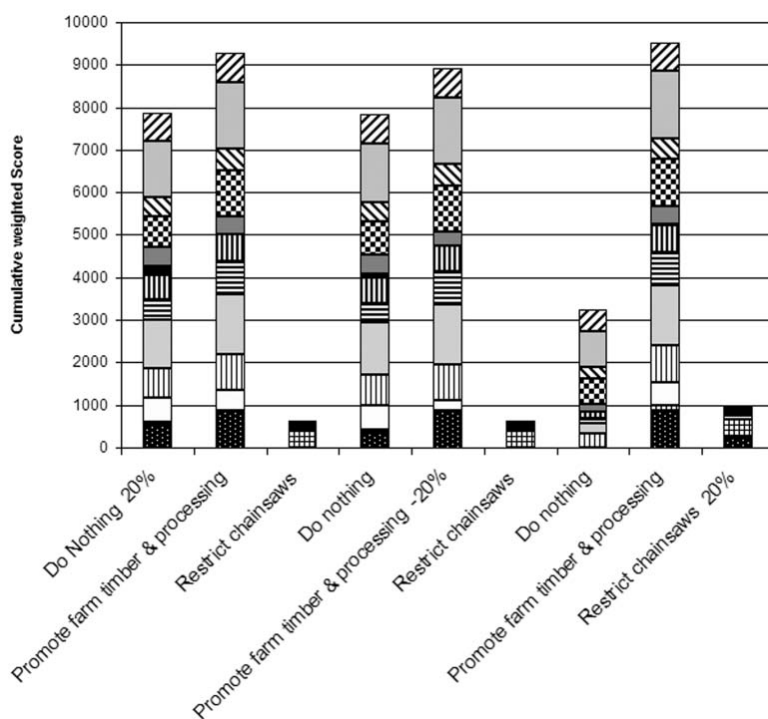


Figure 5.4 Sensitivity of option outcome to changes in option scores.



Key to figures 5.2 - 5.6

- National economy
- Law / Regulation enforcement
- Recovery / efficiency log to sawn timber
- Small timber Business development and opportunity
- Farmer Income diversity (including non-cash savings)
- Agricultural crop / animal productivity
- Fuel wood (Firewood and Charcoal) from farms
- Community involvement, Participation and Decentralisation
- Poverty alleviation / Pro-poor growth
- Afforestation (farm)
- Decrease of farm Soil erosion and improved Water quality and supply
- Decrease of public forest destruction / illegal felling
- Increase of (farm) Flora and Fauna density, diversity and cohesion

Figure 5.5 Sensitivity of options by who decides the weighting.

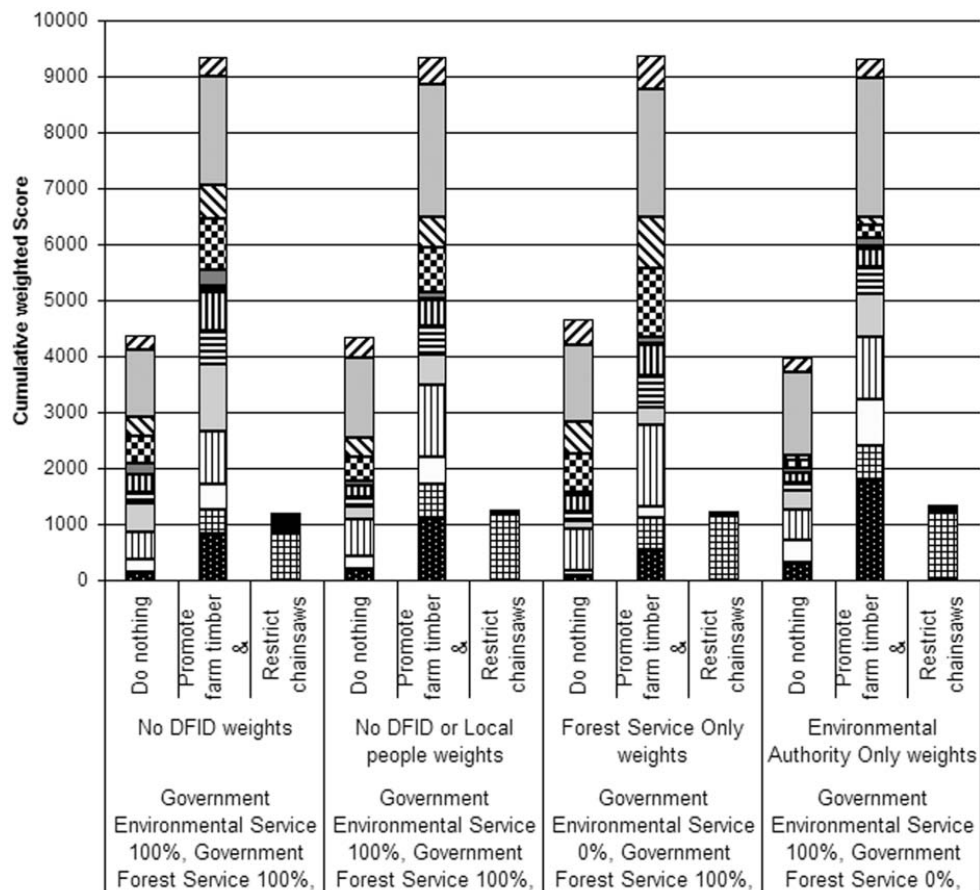
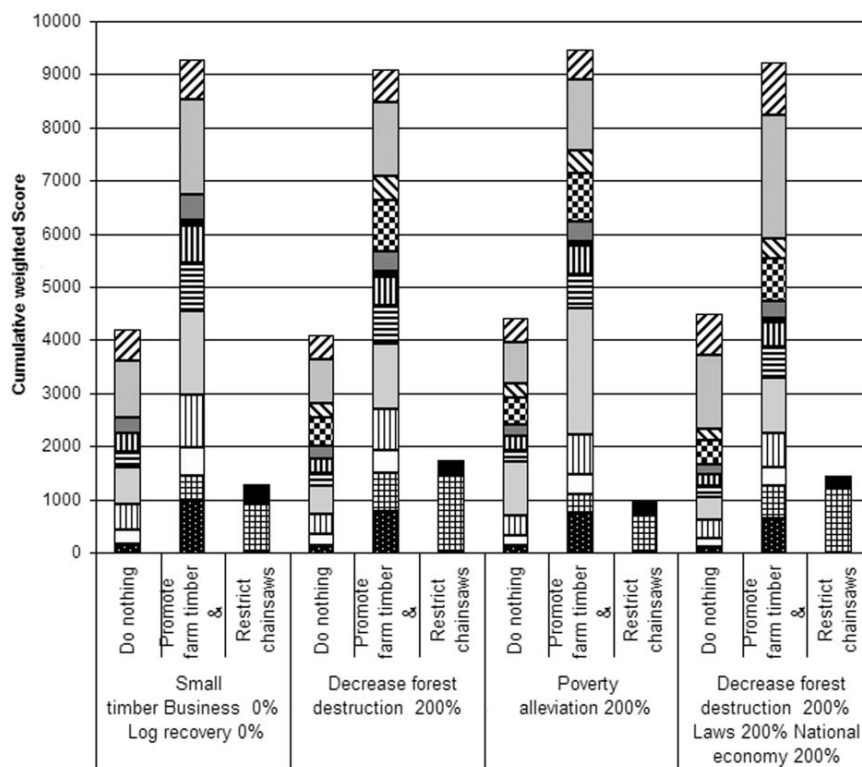


Figure 5.6 Sensitivity of options by changes in criteria weighting



policy option when the 'do nothing' option is increased by 30%, the 'promote' option is decreased by 25% or the 'restrict' option is increased by 220%. The option dominance is affected by the option scores, however they have to change by at least 25% for the 'promote farm timber and processing' policy option not to be the prime choice of action. If sensitivity is applied to an individual or group of criteria, then all scores across the policy options rise accordingly, making no difference between policy options.

Sensitivity to whom decides the weighting

Figure 5.5 shows the sensitivity of the options to changes of who decides the weighting. It is clear that whoever decides the weighting makes very little difference on the outcome of the option choice, in other words policy choice is very insensitive to weighting choices.

Sensitivity of criteria weighting on the options

This shows the sensitivity of the options to changes in criteria weighting. It is clear even with very large changes in criteria weighting it makes very little difference on the outcome of the option choice, in other words policy choice is very insensitive to criteria weighting.

Summary conclusions

The spreadsheet used to assess these policy options is available freely from the project website (<http://chainsaw.gwork.org/>), and, within reason, has been made relatively easy to use and explore the options, criteria and weighting used. Though restricted in its scope, this assessment of the choice of policy options for East Africa suggests that a policy of 'Promoting farm timber and Processing' could be exceedingly beneficial and without question the choice of those presented. Of the other policy options considered 'Do nothing' comes a fairly distant second choice. For reasons not able to be investigated here, such as reducing public expenditure, it may have good reason for being chosen as a policy option compared to 'Promoting farm timber and Processing'. However, this may be short sighted considering the likely benefits it would bring against the criteria considered, including the 'National Economy'. This assessment clearly shows that a policy option of 'Restricting Chainsaws' would be a retrograde step leading to a number of negative consequences with very few benefits. It scored in this assessment very poorly.

It is recommended that the long term policy option of 'Promoting farm timber and Processing' be investigated and costed by Agricultural and Forest Departments of East Africa along with NGO's and other interested parties and funding agencies as it could provide a number of beneficial outcomes from employment through to national self-sufficiency, even with the potential to reduce pressure of illegal logging in natural forests.

6 Conclusions and recommendations

A number of related publications from this project offer a summary to the realities of chainsaw milling, and recommendations on realising its potential for economic, environmental and social benefits. These include popular articles and four policy briefs (see <http://chainsaw.gwork.org/>). Two policy briefs on Kenya and Uganda/DR Congo are covered in detail in the respective case studies in Chapters 4 and 5. The two policy briefs with a global focus, one practical and one policy are presented here in edited form as a summary, following a discussion on the illegal timber trade.

Inter-African trade in illegal timber – an overlooked cause of deforestation?

The following resulted indirectly from work carried out as part of the regional case studies. Whereas the information may be somewhat peripheral to the principle objective of assessing ‘when chainsaw milling makes sense’, it offers an insight into some of the issues facing policy makers.

Where the Congolese forests are really going

Go into most big timber yards in Kampala or Nairobi and you can buy mahogany (Khaya spp.) or muvule/iroko (Milicia excelsa) hardwood from the Democratic Republic of Congo (DR Congo). Some of it may be called ‘Ugandan’, thanks to re-stamping when picked up from ‘no-man’s land’ between the border checkpoints, but its source is often not even hidden. Most of it also has the ‘trademark’ tell-tale markings indicating it was milled by a freehand chainsaw operator and suggesting an illegal origin. It is also resawn and sold as finished products such as furniture or flooring. Rough sawn mahogany costs about US\$150 per cubic metre in DR Congo and retails for US\$650 in Nairobi, the mark up making it worth the risks and easily covering any necessary bribes on route. Timber from DR Congo is also found in timber yards in Tanzania and Sudan, with reports of it making it all the way across the desert to Egypt and Somalia, and is increasingly sold to overseas buyers via the internet.

Demand for timber from developed countries is generally considered, especially within donor communities and environmental groups, as the main cause of tropical deforestation. However, the trade between African countries is rarely mentioned or considered significant. Accepting and monitoring this reality, and reducing demand by supporting existing initiatives to increase timber production in ‘timber-deficit’ regions, are suggested as parallel ways forward.

Global trade in illegal timber is assumed to result in a loss of US\$5 billion annually and a further US\$10 billion to timber producing countries according to the World Bank (FAO,

2005), and is thought to be one of the principal causes for loss of tropical forests worldwide (Hewitt, 2005). The amount of illegal timber being traded has been variously estimated at between one half to the same as the declared legal harvest in a number of countries.

While the importance of this illegal trade in economic and environmental terms is not disputed, it is argued here that current initiatives aimed at reducing imports of illegal timber into Europe or North America may never achieve their desired impacts. This is because they do not consider the effects of the ‘hidden’ internal timber trade within Africa, or Asia or Latin America.

So what of the evidence?

Look at the trucks, containers or stockpiles at any border crossing between DR Congo and Uganda, or the Central African Republic and Chad for example, or visit any timber yard in Nairobi or N’djamena, and it becomes immediately evident that inter-African trade in timber is significant. However, look at books or reports on the illegal timber trade by many organisations, and it becomes paradoxically evident that this is being largely overlooked by those in the developed world working to reduce this trade and ‘save the rainforests’.

In the WWF’s recent report on the illegal timber trade, Hewitt (2005) repeated such myths, arguing that inter-continental export markets were driving deforestation, including especially that in the Congo basin. Other work has been undertaken by Global Witness, the World Conservation Union (IUCN-TRAFFIC) and Forest Monitor, though much more remains to be done and the idea that ‘most is exported’ is still commonly reported.

However, it is becoming increasingly clear that much illegally harvested timber never leaves the African continent, being traded from timber-rich to timber-poor countries, as well as to the rapidly expanding urban centres within each. This trade may well exceed the volumes of illegal timber exported to outside the continent, with exports to Europe already tending to concentrate on timber from legal concessions.

There is clearly substantial traffic of timber from central African forests to East Africa, and from humid West and central Africa to Sahelian and North African countries, and it is likely that similar trading patterns exist between neighbouring timber-rich and timber-poor countries throughout the tropics. Being illegal, however, means that accurate figures are not available.

The volumes involved must be considerable to achieve the profits quoted by the World Bank, but even these may be underestimated. With large amounts of money changing hands in transactions and bribes, some of the stakeholders

directly involved are not open to discussing their business. As one observer on the Congolese border noted, “when you’re facing an AK-47, you don’t ask any questions or take any pictures”.

Such trade may be affected by different national tax regimes or other legislation, but as most of the timber is going from forest to city or desert, it appears to be a case of simple supply and demand in an unregulated ‘open’ market. Rapidly developing urban centres and timber-deficient regions all over Africa and the developing world are creating a ‘timber vacuum’, driving a trade in wood and wood products, often illegally sourced from the nearest remaining natural forests.

What is being done?

Measures are being taken to make the international timber trade more transparent. The most important of these are the FLEG (Forest Law Enforcement and Governance) initiatives, including the FLEGT Action Plan of the European Union and World Bank supported regional AFLEG in Africa, while others exist in Asia and North America. However, these currently only include voluntary agreements, though governments are under pressure from environmental groups and NGOs to make them legally binding.

Even so, measures like FLEG might not be enough, as they are still largely aimed at reducing only inter-continental trade in illegal timber, and in their present form are unlikely to have any significant impact on overland trade within regions or trade to other markets not covered by such agreements such as in East Asia. However, they may provide a valuable model on ways to make the timber trade transparent, but transferring such initiatives to leaky borders, loose enforcers and lawless dealers will be a challenge indeed, and unlikely to succeed.

Also, as logs are being increasingly milled in the forest by chainsaws, restricting their use has also been tried in timber producing countries, and it is true that almost all illegally harvested timber has been felled or sawn by chainsaw. The effects have not been promising, however. In Guyana, 80% of the timber in local markets has been chainsaw milled, legally, and likewise in Ghana though the use of chainsaws is illegal in that country. Widespread corruption is another factor making similar regulations very difficult to enforce.

Ways forward

It thus appears imperative that serious and reliable checks are made to assess the extent of the trade in illegal (and legal) timber across national borders within Africa, including volumes and markets, species and sources, pathways, prices and players, at least in approximate terms, and to compare this to equivalent data on inter-continental trade in both legal and illegally sourced timber. Defining the extent of the problem is required before any recommendations can be suggested and discussed.

More immediate environmental impacts may be possible if stakeholders in developing countries concentrate on improving the monitoring of timber exploitation from legal concessions and ensuring it is sustainably managed, for example by enforcing the use of reduced impact logging and similar practices.

The most advisable way to reduce the demand for timber from timber-deficient regions is to increase their capacity for timber production and processing. With natural forests being increasingly protected for the ‘global good’ and plantations having to compete with agriculture, growing trees for timber outside forests is being increasingly seen as a way forward (Pasicznik, 1999; World Agroforestry Centre, 2005).

Farm forestry has a huge potential to meet the demand for more wood, and the vast drylands can also be turned into productive agroforests when equipped with the appropriate skills and tools (Felker, 2000; Pasicznik, 2000). This, and intensifying production from plantations, will reduce the pressure on natural forests and reduce illegal harvesting. But it will take the efforts of many committed individuals at all levels, and it must and will be done, at least in a forester’s time-scale.

Chainsaw milling – improving timber production and rural livelihoods outside forests

The future of timber production is not from forests

Increasing timber consumption means most countries are now net timber importers. More natural forest is being conserved for ‘the global good’, and what remains has to be protected from conversion to agriculture or urban development and managed sustainably. Plantations will continue to supply high volumes of timber for industry, but this will not be enough – so where is the timber of the future going to come from?

The timber we demand will have to come from outside forests, and farmland and drylands have already showed potential with the application of appropriate knowledge and technology. Some countries such as China, Kenya and India have been pioneers in producing timber from farms and land unsuitable for food production. This should be applauded, highlighted and promoted, and increasing the supply of cheap timber from presently timber-deficit regions will also reduce demand for illegal timber from natural forests.

The potential of chainsaw milling

Outside forests, low tree densities and volumes mean many common forestry practices are not viable. Sawmilling machinery suitable in such situations must be portable, able to efficiently cut small diameter, short and sometimes crooked logs, and of low enough capital cost to be economical

if milling only a few cubic metres a week. Chainsaw mills fit all these criteria.

Mills are simple frames or guides attached to the chainsaw, and a large range is available (see Chapter 1). They have characteristics and requirements making them appropriate for a limited number of operations in forestry but show enormous potential for low volume farm forestry, agroforestry and dryland applications, such as where log extraction and transport is difficult, damaging or too costly, and/or poor form or non-standard log size makes conventional sawmills uneconomic.

Overcoming chainsaw milling myths“

Chainsaw milling is very wasteful, with a wide cut, and produces curved boards with a very rough finish”. This may be true if a part-time operator or worker mills ‘freehand’, but use of a chainsaw attachment and ripping chain produces quality boards with a bandsaw-like finish, much improved recovery, and reduces risks of accidents. Reduced kerf chains are also available.

Chainsaw attachments can also turn timber destined for firewood into sawn timber, processing logs that other sawmills would not accept. Logs as small as 30 cm long or 15 cm diameter can be milled, with timber possible from branch wood, bent, damaged or oversized logs, offcuts, reclaimed building timber, and from street and fence trees likely to contain nails.

Chainsaws and livelihoods

Being relatively low cost and easy to use, chainsaws are accessible to more people than any other means of timber processing, except the axe and handsaw. Pitsawing is still widespread though its use is declining rapidly, being replaced with chainsaw milling. Most chainsaw operators do not own their own saw, however, usually hiring, renting or ‘borrowing’. Many operators are saving up in hope of one day becoming an owner-operator, or even being able to just rent out their machine without having to do the hard work.

All operators say they are better off now than before they began using a chainsaw to fell and/or mill freehand, when most were without regular paid work. But chainsaw milling freehand has a high risk of injury and fatigue, affecting livelihoods. Safety clothing is rarely used in the tropics and even basic precautions are ignored. Removing chain depth gauges is also common, increasing cutting speed but also risks of ‘kickback’, and poor posture, high noise and vibration levels have other long-term impacts.

Banking with planking?

Trees are savings banks. In agriculture and agroforestry systems where sawmilling is available, farmers can turn them into cash during low-income years, during droughts, if crop/livestock prices fall, or if money is required to pay for hospital

or school fees, marriages or funerals. Inexpensive portable sawmills can add greatly to the value of withdrawals from the ‘bank’, by adding value through milling. The revenue from sawn timber will be much larger than that from selling standing trees to merchants, who may also exploit farmers’ financial plight.

On farms and in drylands, trees have rarely played a significant role in rural incomes, though increasingly the need for diversification and indirect benefits are encouraging tree planting. A greater quantity, quality and diversity of timber products will have secondary effects locally, stimulating further processing such as furniture or craft making, transport, and a trade in tools, materials and equipment. More money to tree owners and processors from value addition will increase cash flow, chances for re-investment, and general benefits to the local economy. Adding value to trees will also improve chances for more planting and tending.

Ways forward?

The technology for low-cost wood conversion exists, some of it over 50 years old, and news will spread rapidly once the potential is shown. Markets exist, and will adapt as soon as supplies increase. But skills need to be taught, with training identified as one of the most important needs. This is a great challenge, and one not for extension workers alone, but also in convincing machinery manufacturers and dealers who will gain from developing enterprises, that it is in their best interests to invest in such knowledge sharing.

Turning farmlands and drylands into timber producing areas, equipped with the appropriate skills and tools, is a realistic goal. But to achieve this will take the efforts of many committed individuals at all levels, to raise awareness and provide training, equipment and markets. This will ensure that chainsaw milling makes a positive – rather than a negative – contribution to rural livelihoods and forest conservation.

Chainsaws, milling and regulation

The problem with chainsaws

Chainsaws are highly portable, relatively cheap to hire or buy, very efficient, and the same tool used by one man to fell, crosscut and mill a large tree in under a day. There are, however, increasing concerns about illegal logging and deforestation in tropical forests where there are still high volumes of valuable timber. Inadequate laws or enforcement benefit illicit cutting and over-exploitation, especially in remote locations. Whereas it is true that chainsaws are implicated in most illegally harvested timber, it is clearly not the prime cause, merely a tool in the operation.

But in contrast to the negative environmental effects of illegal chainsaw logging and milling, such crime often allows more money to feed back to poorer people in forest-dependent communities as compared to legal harvesting, usually run by large overseas companies.

Attempts to restrict their use

Restrictions on the ownership and/or use of chainsaws have been tried, but with mixed effects. In Ghana, 80% of the timber in local markets is milled freehand even though the practice is illegal. In Uganda, it is illegal to mill timber freehand, and due to such timber being easy to identify thanks to the 'trademark' chainsaw marks, enforcement is relatively easy with many truck loads of timber and chainsaws apparently confiscated. Many others, however, get through.

However, as this report has shown it is very possible to produce chainsaw milled timber without the 'trademark' chainsaw marks using guidance systems. Clearly, however, regulating or banning the use of chainsaws in the context of inadequate forest laws or enforcement is unlikely to succeed and may just change the tools used. There is no single right answer, each situation being quite different, though there is some consensus on issues to consider.

Chainsaws now seen in a new light

Characteristics that make chainsaws suitable for illicit activities can also aid forest conservation. Certainly, processing trees where they fall has environmental benefits over whole log extraction, and promoting the use of low capital cost processing equipment allows opportunities for more of the local community to engage in forest operations. In addition, they are being increasingly seen as suitable for milling scattered trees on farms, drylands and in towns, thus reducing the pressure on forests as the main suppliers of timber.

Chainsaw milling is economically viable in certain situations, increasing revenues for the very poor. However, it is likely to have negative impacts especially on the environment if allowed to be used without any control of

Policy Comments

The role for regulation in chainsaw ownership/ use

- ❖ *Is it a sensible way to discourage illegal felling? - the evidence suggests not*
- ❖ *decide best policies, who polices implementation on tree felling and timber sales*
- ❖ *implement existing and improved regulation on tree felling and timber sales*
- ❖ *license chainsaws and milling equipment as a last resort*

The case for certification type chain of custody of production and trade

- ❖ *improve transparency in the chain of custody*
- ❖ *establish grower, miller and trader associations*
- ❖ *build consumer and commercial confidence*
- ❖ *problem is that it is expensive, demands high levels of expertise from farmers and millers which they are unlikely to have, suitable for high value export markets who demand it*
- ❖ *Tree felling permits accompanying sawn timber, part of the certification process, a simpler and cheaper method so long as it is enforced and checked*

The time for training in chainsaw use and milling

- ❖ *develop a national training programme*
- ❖ *invite manufacturers and dealers to be involved*
- ❖ *involve timber processors and manufacturers*

tree felling. Existing regulations and their enforcement are clearly inadequate, so alternatives are required, involving governments, local people and/ businesses commercially involved in timber, chainsaws and milling attachments.

The rise and role of chainsaw milling attachments

With freehand chainsaw milling there is a high risk of injury with generally poor timber quality and recovery. However, there exists a wide range of frames or guides that attach to a chainsaw making it safer, accurate and more efficient, but these are rarely used in the tropics. This work confirmed the potential for such simple technology in a range of situations both inside and outside forests.

Promoting the use of such chainsaw mills and adequate training are seen as ways to persuade freehand operators to give up their currently dangerous, inefficient and largely illegal though lucrative activities. Attach a frame, change the chain, take a course, get a license, and make more money from fewer trees, equitably and sustainably. Such changes are unlikely to happen quickly enough on their own without the efforts and insights of officials within forest departments to see the need for change, to draft new policies and regulations, and to push them through the legal system. Many other organisations and companies will agree with these aims, and eliciting their support is likely to assist the process.

Suggested changes to policy and regulation to improve use of chainsaws in timber processing

1. *National forest departments to take responsibility and lead in making necessary changes to policy, law, regulation, enforcement and penalties for tree felling and wood product sales.*
2. *Clarify any ambiguities in existing laws pertaining to chainsaw and sawmill ownership and use.*
3. *Reduce import taxes or tariffs on chainsaw milling attachments that all improve safety, efficiency and recovery, to encourage their greater availability.*
4. *Collect details of all importers and dealers of chainsaws, milling equipment, spares and accessories, to be included in a national register.*
5. *Insist dealers provide records on numbers imported and sold, including buyers' names and addresses.*
6. *License chainsaws and mills nationally, owners to state the purpose and where used, and chainsaw operators requiring a permit, both renewable annually.*
7. *Issue tree felling permits lodged in a central or regional database (including species and likely sawn volume) that accompany sawn timber that is then enforced and checked in transit or at point of sale.*
8. *Institute a national policy on developing and promoting training courses on chainsaw safety, use, maintenance and milling, also timber drying.*
9. *Eventually, make the issuing of chainsaw licenses and permits dependent on whether a training course has been attended.*
10. *Eventually, make the milling or transport of freehand chainsaw milled timber illegal, irrespective of origin (country or forest type), readily enforced due to the presence of the tell-tale markings.*

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