Factsheet

Manually operated sulkies

MINISTRY FOR FOREIGN AFFAIRS OF FINLAND

RECOFTC THE CENTER FOR PEOPLE AND FORESTS

Manually operated sulkies

RECOFTC - The Center for People and Forests

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Table of contents

Figures

Tables

1. History and development

Current logging sulky and logging arch models originated from animal-drawn wooden straight axis logging charts and arches, which were the basic log transport tools in forestry operations until the 1930s when they were gradually replaced by tractor-based systems.

Two-wheeled manual sulkies were developed in the 1970s for use in the tropics by forest development projects of mainly Scandinavian countries. In its final development stage, a **sulky with double bogie wheels** was designed in 1985 in Finland and applied widely in east African countries and the Philippines under the FINNIDA APPRODEV project. In recent years, larger- and stronger- framed models have also been developed for tractor and all-terrain vehicle (ATV) operations, which will be covered in a separate factsheet.

Logging sulkies are in most cases the most appropriate systems for improving small scale forwarding operations in smallholder (plantation) and community (natural forest) operations, particularly where animal ex-traction has not been practiced before.

Figure 1. Historical logging sulky/arch circa 1900 (www.toolmonger.com/2009/04/14/antique-tools-logging-gear/)

2. Design features

In its basic design, a logging sulky consists of two wheels with a straight or arched axis elevated at least 30 centimeters (cm) above the mid-wheel level. The sulky serves the dual purpose of lifting and transporting (skidding) logs, either in full suspension above ground (see Annex: "Suppliers": www.mistersawmill.com) or dragging with one-end suspended. The elevation of the fixation point of the log above the wheel center determines the force required for lifting and the total diameter for single or bundled logs. Logs can be attached either with ropes, choker chains hooked into a slotted notch bar (iron angle) on top of the axis or hook tongs (not suitable for bundles). It is recommended that on level ground, the load be suspended to reduce friction during extraction. On sloping terrain (maximum slope of 40 percent), the load should be dragged on the ground to provide braking power through friction. These options should be considered when designing the distance between handle and axis. An extendable handle bar can also be employed to adjust for different load lengths.

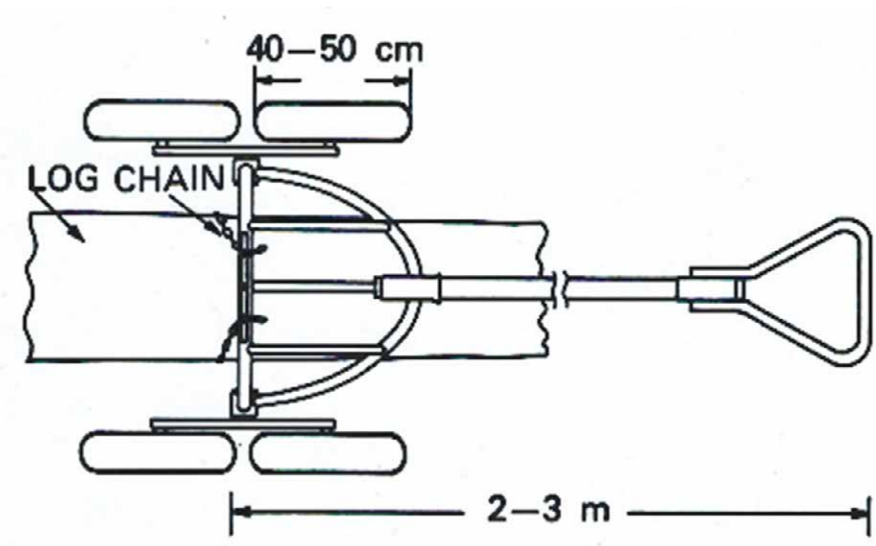


Figure 2. Basic design and horizontal dimensions of bogie type logging sulky (Kantola & Harstela 1988)

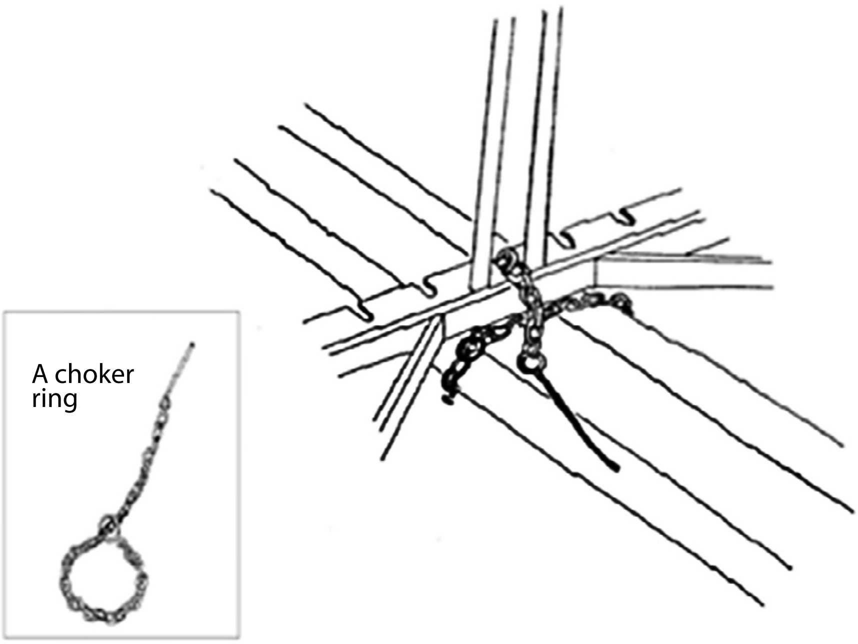


Figure 3. Notch bar for chain attachment with choker coupling (Seymore, M 1996)

There are a few manufacturers and international suppliers (see Annex) for logging sulkies. However, transport costs and import taxes will in most cases make importation too expensive. Moreover, the relatively simple design of this equipment can be locally produced by welding shops, which at the minimum, only require gas welding and steel water pipe bending equipment.

Figure 4. Commercially produced hand sulky with chain choker system. Note protective angles in front of the wheels (www.norwoodsawmills.com)

The weight of the sulky is a decisive factor in terms of ergonomics, especially if work will be done on sloping terrain. Harstela (1986) compared the pulling forces of different bogie constructions:

(1)	Two wheel axle weight of sulky	25 kg	14.5 kp[1] pulling force
(2)	Two wheel axle weight of sulky	16 kg	12.6 kp
(3)	Bogie double wheel weight of sulky	35 kg	10.6 kp

Loading capacity is normally around 125 kilogram (kg) for light frame sulkies and 200 kg for heavier frame two-wheel sulkies, while 250 to 300 kg can be loaded on bogie types. For higher loading capacity, the sulky must be equipped with hand winches (see www.mistersawmill.com in the Annex) and adapted to three-to four-person teams. Most studies on hand sulkies indicate that weight (25 vs. 50 kg) will affect productivity (1.6 vs. 1.0 meter (m)^3/hour) by as much as 30 percent on gentle slopes (Ole-Meiludie and Omes 1979). Thus, weight limitation is an essential consideration in any sulky design.

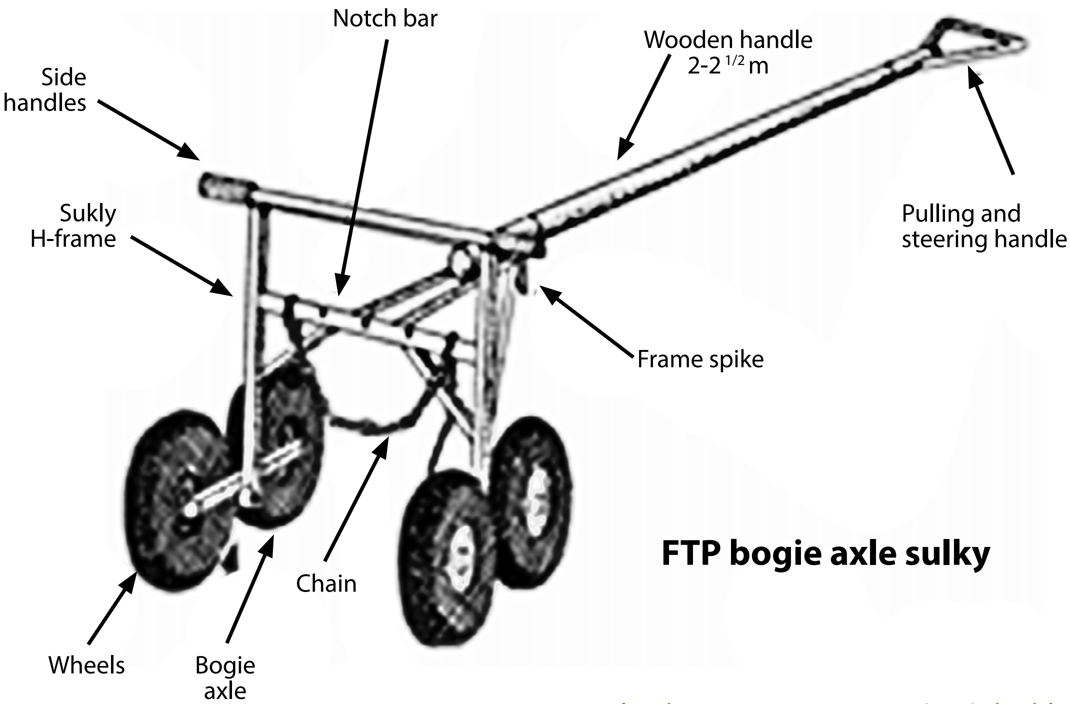


Figure 5. Finland training programme (FTP) double wheel bogie sulky (Seymore, M 1996, Kantola M & Harstela, P 1988)

1 kilopond

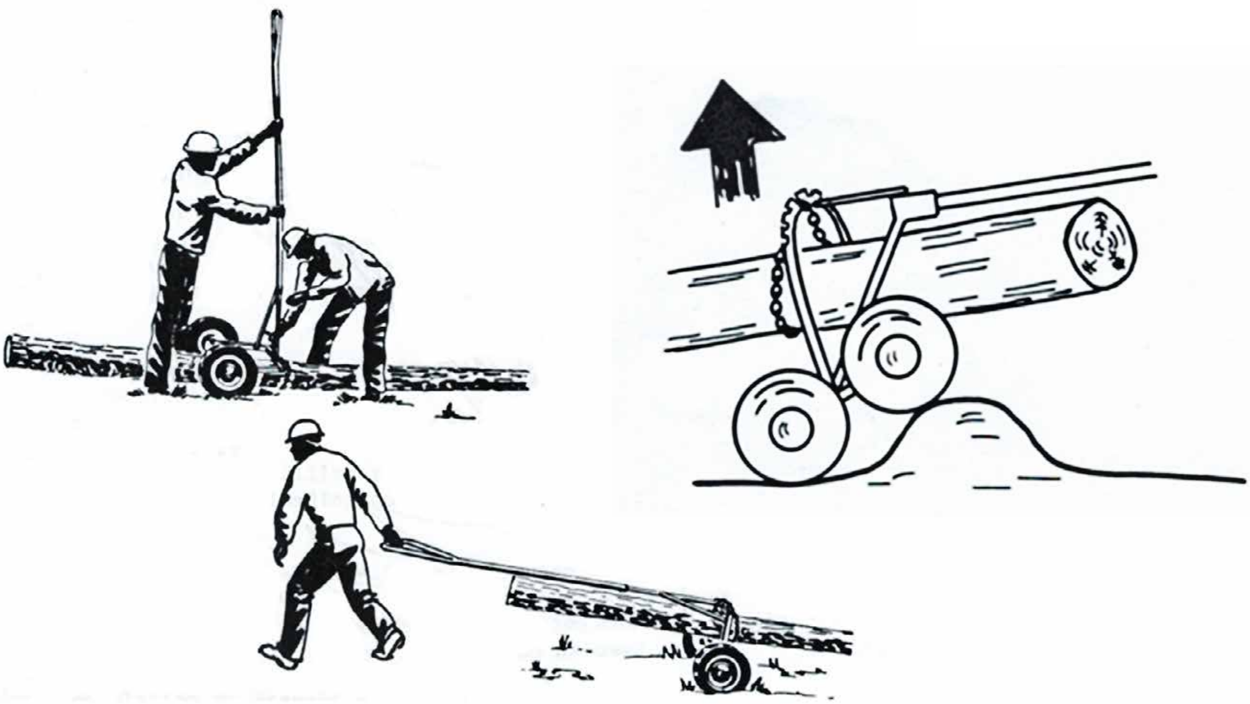
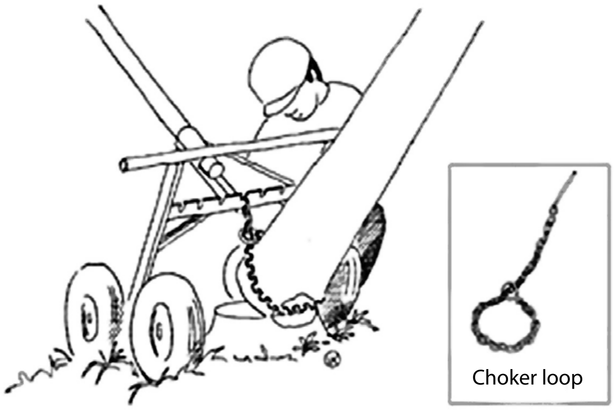


Figure 6. Working with the logging sulky

3. Other sulky applications

During felling operations, hang-ups (trees entangled in canopy) are the potential death traps commonly encountered by forest workers. Sulkies can provide safe and efficient solutions in such risky situations. After removal (preferably by axe) of the **hinge** (holding wood between felling sink and back cut), either sulkies with **choker chains** or special sulky type **felling aids** (see Annex: "Suppliers" – Grube-Muenchehof Model) can be used to release and bring down the separated stem along paths that have been carefully cleared in advance.



3.1 Sulkies for bamboo extraction

Extraction of bamboo from secondary unmanaged forests in northern Lao PDR requires a special type of sulky that enables the downhill forwarding of economically viable loads. Such a sulky has to fulfill three key requirements:

1. Allow bundling and holding of bamboo culms in loads of up to 250 kg using various suspension positions to accommodate an extendable handle bar (1.0 m extension);
2. Allow high maneuverability of the sulky in-between trees and bamboo clumps along overgrown extraction routes while loaded with culms of up to 15 m in length; and
3. Provide a braking mechanism that allows emergency stops when extracting on steep slopes.

These criteria were addressed with design elements shown in Figure 7. The sulky was manufactured from a small two-wheel (50 cm diameter) axle with a 2.5 m handlebar. In its initial stage, the bar was constructed with an inserted handle that made possible the testing of various bar lengths. A clamp-type holding bank was elevated about 30 cm above the axle and connected with a 10 cm diameter ball bearing on two steel plates with a small center axis that allows free turning of the wheels by more than 90o below the bamboo loads. The clamps have attachment hooks and guide plates on each side of the top section for the attachment of 5 cm-wide ratchet straps for bundling bamboo culms, with these straps allowing readjustment in case the culms slide apart during extraction. The inside of the clamps are covered with consecutive 3x3 cm sharpened teeth to improve grip on the slippery bamboo culms. The clamps and support are made from 6-8 cm x 60 cm steel strips.

A spade-like brake was also attached to the first upward bend of the handle bar. Simply pressing the handlebar towards the ground on steep and slippery terrain thus makes for safe emergency stops.

Figure 7. Bamboo sulky. Note the clamping device and the extendable handle bar with an inside pipe of about 100 cm and the spade-like emergency brake.

3.2 Sulkies in manual steep slope extraction

Hand sulkies reach their ergonomical limits on steeper slopes (above 30o). In such situations, the use of pulleys (for details, please see the hand tool factsheet) as shown in Figure 8 is recommended. Using pulleys will allow either safe downhill extraction with a counterweight or easier uphill movement by using the downhill force of the empty sulky and downhill pulling force of the operators. It is advisable that such systems also adopt the spade-type safety break system as illustrated in the bamboo sulky (Figure 7).

Figure 8. Use of pulleys combined with counterweights on steep slopes

3.3 Draught animal sulky

Draught animals, such as oxen, buffaloes, horses and donkeys can be used in combination with the sulky to transport heavy loads. Putting loads on wheels reduces skidding resistance and enables animals to pull heavier loads. For safety reasons, the uphill pulling of sulkies using draught animals on steep slopes, either directly or with the aid of pulleys, is quite dangerous and is not recommended. In such cases, dragging logs on the ground is the preferred method.

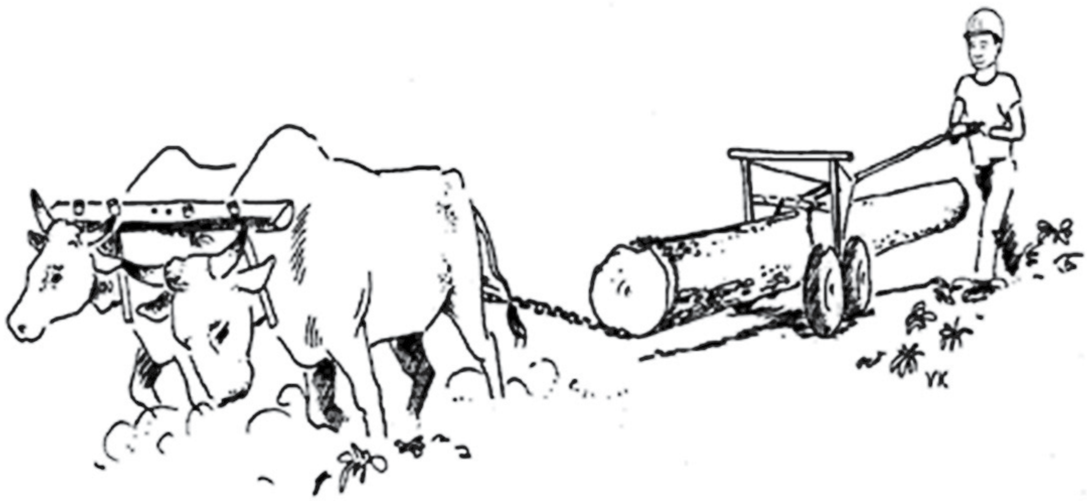


Figure 9. Sulky in combination with draught animals (Seymore 1996)

4. Productivity and efficiency in sulky extraction of timber

4.1 Timber

Several studies were carried out between 1970 and 1995 by Finland- and Norway-supported projects on hand sulky extraction of timber. The results of some of these studies are summarized in Table 1.

Table 1. Productivity for two-man sulky teams under different site conditions (Seymore 1996)

Study description	Terrain	Distance	Slope	Production m^3/sulky/hr
Kotka, Finland May 1988 Pine logs (av. 0.2 m^3)	smooth	50 m	flat	1.4
Kafubu, Zambia May 1991 Pine logs (av. 0.15 m^3)	smooth	95 m	flat	1.6 (excluding pilling)
Machinga, Malawi September 1992 8m poles (av. 0.2 m^3)	small rocks	180 m 35 m	15% down 10% down	1.2 1.6
Mt.Meru, Tanzania July 1993 pine logs (av. 0.08 m^3)	small rocks	15 m	10% down	2.4
Bislig, Philippines March 1994 falcataria logs (0.31 m^3)	small hills & very muddy	50 m 250 m 45 m	flat flat 35% down	2.8 1.6 1.2

The figures in table 1 and some further studies by Skaar (1975), Ole-Meiludie (1984) and Saarilahti (1992) illustrate skidding outputs in relation to extraction distances (moderate slopes) for two-man sulky skidding teams on prepared trails with average loads of 100-200 kg.

Skidding distance (m)	10	40	80
Skidding output (m^3/ day)	12-18	8-13	5-10
Labour productivity (m^3/person/day)	6-9	4-6.5	2.5-5

4.2 Bamboo

Very few productivity figures on bamboo extraction, either from plantations or natural stands, are available (China, Philippines and Ecuador) and those that have been published are incomplete (without figures on distance, slope, volume-piece ratios, etc.). For these reasons, the figures cannot be transposed to other sites. None of these studies applied sulkies involving operations from bamboo extraction to roadside activities. The results obtained by Salakka (2014) are the first ever published for these parameters.

The bamboo sulky was developed to carry loads exceeding 200 kg. In its original design, its weight was over 85 kg. A lighter version is currently being built. According to the opinion of the operators used in the Salakka (2014) study, a load size of 120 kg is ergonomically suitable when two operators are pulling the sulky. The forwarding distance used in the trial cycles was 350 meters. Topography was moderately sloped (20 percent) along the extraction route and flat (15 percent maximum) with soft ground on paddy terraces. Table 2 gives the time breakdown of activities in bamboo extraction. In comparison to timber extraction, the loading time was around 20 to 30 percent higher, attributed to the smaller size of the material being loaded. Pre-bundling of bamboo culms, which reduces cycle time, was not possible due to the top loading character of the clamp bank.

Table 2: Time distribution for sulky extraction of bamboo over 350 meters

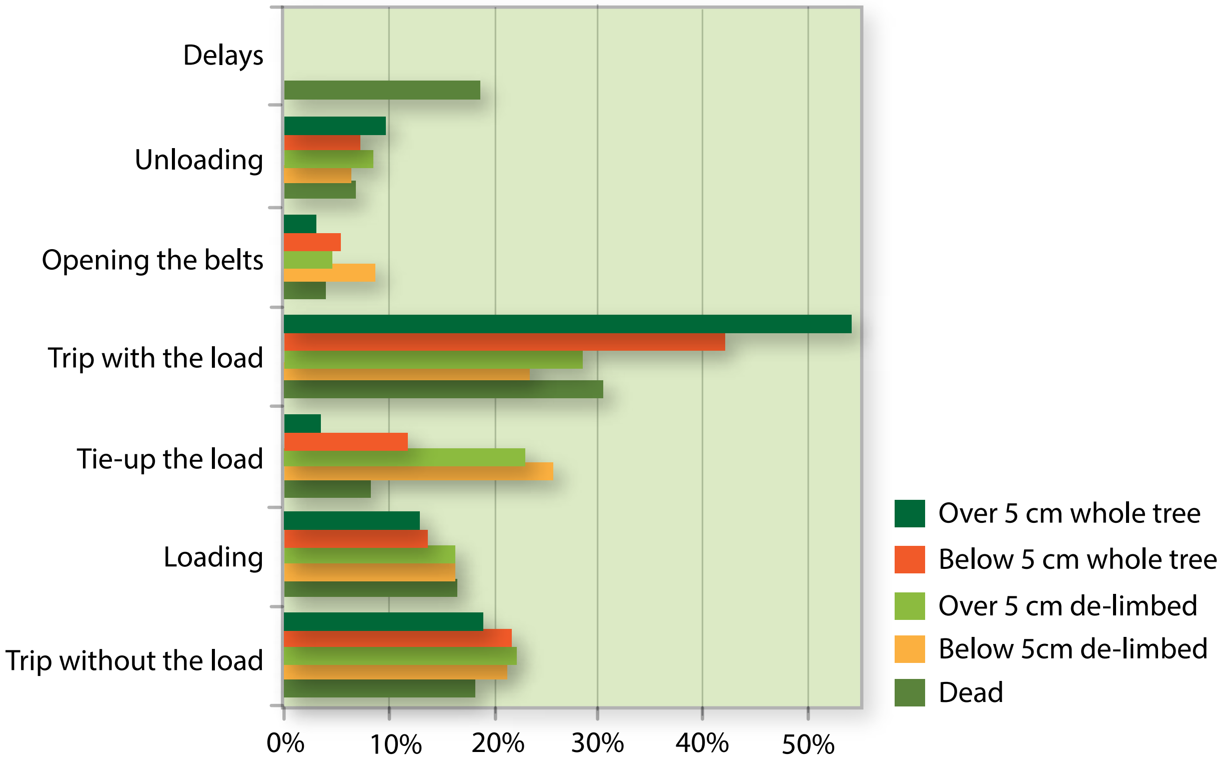


Table 3: Productivity for two-man teams in relation to bamboo culm characteristics over an extraction distance of 350 meters

	Productivity, t/h	Average load, kg	Average cycle time, min
Dead	0.283	134	28.4
Below 5 cm de-limbed	0.302	106	21.1
Over 5 cm de-limbed	0.467	155	20.0
Below 5 cm whole tree	0.236	85	21.5
Over 5 cm whole tree	0.200	84	25.3

Given the extraction distance and the extremely low range of volume (weight-piece ratio of 8-20 kg per piece, productivity figures are surprisingly high compared to timber (50-200 kg per piece). In terms of labor productivity, extraction will be in the range of 0.8-2.0 tons/person/day. Given site conditions, the use of the sulky increases labor productivity in bamboo extraction by at least three to five times compared to carrying by hand.

Recommendations

Sulkies offer the ideal solution for a first step improvement in labor efficiency from purely manual extraction, as applied to flat terrain, downhill and even uphill conditions. The average load can be improved from 30-50 kg per person to 150-200 kg on flat terrain and 250-280 kg for downhill extraction. This can improve extraction efficiency by a factor of at least two and up to five and can result in considerable savings on labor cost. Sulkies can be built in most rural environments with locally available (often scrap) materials. Due to a sulky's low cost of construction (US$ 200-300), machine cost for the systems is negligible and can be recovered over very short periods. The system can, moreover, be upgraded into more solid and heavier logging arches that can be drawn by animals, four-wheel tractors, hand tractors or all-terrain vehicles, as discussed in their respective factsheets.

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Annex

1. Suppliers

www.grube.de (Germany)

www.norwoodsawmills.com
(Please see Figure 4).

www.hakmet.com (Canada)

www.mistersawmill.com (USA)

2. Machine Cost Calculation

Manufacturer: ______________________ Model: ______________ HP: ___________________

Purchase price: $ ______________________

Total price of transportation to site: $ ______________________

Total: $ ______________________

(P)	INITIAL INVESTMENT	$_______________
(S)	Salvage Value (____% of P)	$_______________
(N)	Estimated Life: ____ years	
(SH)	Scheduled operating time: ___ hrs/yr	
(U)	Utilization: ___ %	
(H)	Productive time ____ hrs/yr	
(AVI)	Average value of yearly investment **AVI = [((P-S)(N+1))/2N]+S**	$_________/yr

I. Fixed cost:	
Depreciation= (P-S)/N	$_______/yr
Interest (____ %), Insurance (____ %), Taxes (____ %) Total ____ % x ($____/yr)	$_______/yr
(1) Fixed cost per year	$_______
(2) Fixed cost per H (1÷H)	$_______
II. Operating cost: (based on productive time)	
Maintenance and repair (_____% x ((P-S)/(N x H))	$_______
Fuel (____ L x $____/L)	$_______
Oil & lubricants	$_______
Tires (1.15 x (tire cost)/tire life in hrs.)	$_______
(3) Operating cost per H	$_______
III. Machine cost per H (without labor) (2+3)	$_______
IV. Labor cost ($_____/hr ÷U)	$_______
V. Machine cost per productive hr. with labor (III + IV)	$_______

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