Wood Harvesting

Basic knowledge

The Wood Harvesting Module provides guidance to forest managers on best practices in wood harvesting. It addresses the main aspects of harvesting operations, including planning, road construction, felling, extraction, transport and post-harvest assessment.

The module provides basic and more detailed information on wood harvesting, as well as links to wood harvesting tools and case studies of effective harvesting.

Wood harvesting encompasses felling, extraction, on site/landing processing, and loading of trees, logs or other tree parts onto trucks. Harvesting has a lasting impact on forest structure and ecosystem functioning. Environmentally sound forest harvesting and transport operations are therefore essential components of sustainable forestry. Good practices begin with careful planning, trained and motivated workers with technically competent supervisors. Six areas are particularly critical from a sustainability standpoint. They are planning, roads, felling, extraction, long-distance transport and post-harvest assessment.

Planning is broadly done at three levels, the strategic, tactical and operational levels. Strategic plans span over long periods and large areas. Tactical plans cover shorter periods typically at landscape or watershed level. Operational plans incorporate actions needed to conduct operations.

Roads built in connection to harvesting are typically classified as haul roads stretching from landing to mill or shipping point, feeder roads built to reduce skidding/forwarding distances, strip roads to extract wood from stump to landing, and access roads e.g. for labour, material and connection to administrative centres. Poor practices can be very damaging and costly, e.g. causing erosion and landslides. Competent staff should be engaged in planning and construction of roads. Adequate maps need to be available. Areas of importance include drainage, avoidance of steep grades, avoidance of sensitive areas and crossing of waterways.

Felling should be done to accommodate extraction and avoid damage to residual trees, i.e. a form of wood transport; this is sometimes called directional felling. Felling is done using axes, saws, chainsaws, feller bunchers or harvesters.

Extraction by means of dragging stems or logs on the ground is called skidding. Skidding can be done by humans, draught animals or by machines, so called skidders. Forwarding refers to stems or logs carried by humans or on a trailer after an animal or a machine (forwarder). Skidders and forwarders can be wheeled or tracked. Crawler tractors (bulldozers) are often used for skidding in tropical rain forests.

A number of harvesting systems exist. None of the systems are inherently better or worse. Harvesting systems are classified as, full tree systems, where trees are extracted to landing or plant with the full crown, tree length systems, where tops and branches have been removed prior to extraction, and short wood systems, where topping, debranching and cross cutting are done close to the stump. Full tree harvesting is a rare practice. The tree length systems is the most common method for industrial wood, it dominates in operations in natural forests in the tropics. The shortwood system is on the increase. “Reduced Impact Logging” in rain forests is normally done using the tree length system, with extraction by means of crawler tractors, skidders or cable systems.

Post-harvest assessments include checking that operational standards have been sufficient and that legal prescriptions and management policies have been adhered to. Post-harvest actions may include shutting down logging roads, rehabilitating harvested areas and landings.

Wood harvesting contributes to SDGs:

In more depth

Below follows information on a number of key issues in wood harvesting and forest engineering. There is an emphasis on issues relating to tropical forestry. For more detailed guidelines on forest operations, readers are recommended to consult an appropriate code of practice, e.g. the FAO Model Code of Harvesting Practice from 1996. Codes of practice are normally very useful compilations of knowledge and experience.

Harvest planning

The role of planning in sustainable forest management cannot be enough stressed. Below follows some brief introductory notes about planning. There is a wealth of publications and other tools available beyond what is suggested in this module.

Meaningful harvest plans involve a good understanding of the objectives of the management plan, the harvesting systems available and the logistics required. Information on site data is also needed.

Planning is broadly done at three levels: strategic, tactical and operational. **Strategic plans** span over long periods and large areas and may involve e.g. management guidelines, construction of facilities and management intensity. **Tactical plans** cover shorter periods typically at landscape or watershed level. They can be seen as the implementation of strategic plans. **Operational plans** incorporate actions needed to conduct operations on the ground.

Geographical Information Systems (GIS) are now generally used in planning systems. They permit several factors to be taken into account simultaneously in the planning process. The development of GPS receivers and digital data loggers have improved GIS greatly the last years.

Felling

Felling should be viewed as wood transport, where the first few and most expensive metres matter. Facilitation of extraction is therefore a primary concern. Felling should further not cause damage to logs. Damage to residual stand should also be taken into account.

Trees are felled manually using axes, cross cut saws or bow saws. Some delimbing is done using axes and machetes. The bow saw has largely replaced the cross cut saw for trees up to 30 cm in diameter. Most felling in forestry is done by chainsaws today.

Felling can be roughly classified as:

- Uncontrolled felling. No attempt to influence the direction a tree falls, safety precautions and sound working techniques are disregarded.
- Semi-controlled felling. Fellers have a fair idea where a tree will fall but do not influence the lay. Basic rules are observed e.g. rudimentary cutting of felling notches and back cuts.
- Controlled/organised felling. Scarfs are well-executed, back cuts are well placed and hinges in accordance with desired felling directions.
- Directional felling. Fellers are fully capable of felling trees in the direction desired, which may deviate considerably from the natural lean. Operational and silvicultural aspects are taken into account. Additional tools like wedges and winches are used.
- High-tech felling. Fully mechanised felling using feller-bunchers or harvesters, and techniques/machines in development. Generally not feasible for large trees.

Skills needed to perform organised or directional felling must be learnt on ground, preferably under supervision of professional instructors. Guidelines for “typical cases” are available, e.g. trees with or without lean, with or without buttresses, according to lean, 45o or 90o to the direction of the lean. In reality however, there is only “unique cases”.

Extraction

Extraction is the moving of stems from the forest or to the roadside or to a landing is generally done using the techniques described below.

Ground-Based Extraction

Pre-planning of extraction improves efficiency of extraction, increases safety and reduces damage to soil and residual trees.

The mode of work in natural forest is influenced by e.g. terrain, road and landing construction costs, silvicultural system and volume to be removed per hectare. Some systems of organising extraction can be distinguished: parallel, radial, starburst, random, herringbone and branching. In steep terrain parallel and branched strip roads are generally preferred. Trees are, if possible, to be felled so that extraction

machines do not have to leave the strip road. Strip road spacing varies with site conditions and extraction rates, but is generally wider than in planted forests.

Strip roads should be flagged or opened up before felling commences. This is to make sure that they are passable, and to help fellers choose felling directions. Sharp bends should be avoided.

In planted forests strip roads can be more or less parallel, generally at a spacing of 30 to 60 m.

Cable Extraction

In cable logging one or two suspended cables are used to convey logs from forest to landing. Cables are operated by a winching machine (yarder or hauler) placed at the landing or the opposite end of the cableway.

Cable logging systems are generally more expensive than ground based extraction systems in areas where ground skidding is an option. Soil damage is comparatively low in this system. Skilled staff is required at all levels of the operation.

Cable logging systems are divided into highlead or skyline systems. In highlead yarding logs or trees are dragged from the stump to the landing. Yarding distances seldom exceed 300 m. The system is suitable for clear felling.

In skyline yarding/cable crane systems, one or both ends of logs or trees are suspended during transport. This benefits efficiency and reduces ground disturbance. A skyline cable is mounted on a spar tree and runs to an anchor fixed at the opposite end of the cableway. A wheeled carrier mechanism, a carriage, rides along the skyline cable to carry loads to landings and empty chokers back to the felling site. Loads are attached to the carriage by a cable called the skidding line. Yarding distances can be much longer than for highlead systems.

Harvesting planted forests in the tropics

Planted forests are generally rather uniform in terms of tree size and properties. The smaller size and homogeneity of the trees means that there is more options in harvesting than for e.g. rain forest. Changing harvesting systems from a tree length systems to a short wood, or vice versa, is complicated, as timber trucks will have to be rebuilt or replaced, and log handling machinery and routines at the mill site will have to change.

Residual stand damage is not an issue in final fellings, but can be in intermediate harvests. Directional felling towards pre-aligned strip roads reduces damage. Felling and extraction should start at the end of strip roads. Strip roads can be aligned more or less parallel to each other. Strip roads for extraction can be aligned at spacings over 30 metres. Strip roads for mechanised felling normally need to be aligned 20 to 25 m apart.

Plantations are not necessarily production forests. Harvesting should be “in tune” with the functions of the plantation.

Choice of appropriate technology

Harvesting can be done using many different methods and systems. The appropriate level depends on a number of factors often related to culture, cost structures, logistics and labour. Some examples of factors that may be considered are:

Availability of unskilled and skilled labour	Potential labour unrest
Cost and productivity of skilled and unskilled labour Infrastructure in place	Availability of capital
	Equipment and parts import limits
Culture (work hours, work season)	Availability of parts, maintenance facilities
Physical ability to do the work (log size, transport distance, slope, heat, humidity)	Prospective changes in labour laws
	Prospective changes in equipment or fuel costs
Profitability per cubic metre produced by manual, animal, motor manual, and mechanised system	Availability of training for the work force
	Ability to retain the workforce
Labour laws (ability to terminate employment, benefits)	Legislation, regulations, or permit requirements
Remoteness of work sites (back home each day, each weekend, a few times per year)	Wood processing alternatives
	Business requirements, mills may be equipped to accept certain wood forms (e.g. whole stems or short logs)
Social infrastructure (housing, schools, hospitals)	

Technical and physical factors include e.g.:

- Timber characteristics (tree size, volume per hectare, timber quality)
- Terrain (slope, ground profile, streams, wetlands, gullies and roughness)
- Soil (texture, moisture content and seasonal impact)

- Weather and climate, unfavourable weather can affect soil disturbance and work safety
- Silvicultural system (machine size and manoeuvrability) <dir>
- Mechanisation generally needs good infrastructure, communications, mechanical services and efficient management to be effective

Reduced impact logging in tropical forests
Increasing alarm, particularly in the tropics, at damage levels and logging waste in poorly planned logging operations using heavy machinery has leaded to the adoptions of techniques and methods to reduce these problems, Reduced Impact Logging (RIL).

There are a number of definitions of RIL. One is:

The intensively planned and carefully controlled implementation of timber harvesting operations to minimise the environmental impact on forest stands and soils

A number of Codes of Practice and other standards have been written, and they are included as tools or cases in the present module. Measures and treatments typically included are:

- Pre-harvest inventory and the mapping of trees
- Pre-harvesting planning of roads, skid trails and landings done using topographic maps.
- Pre-harvest vine/climber-cutting in areas where big vines connect tree crowns
- Prescriptions on extraction rates to control damage and secure future production
- Construction of roads, landings and skid trails following environmentally friendly design guidelines
- Appropriate felling and bucking techniques including directional felling, cutting stumps low to the ground to avoid waste, and the optimal crosscutting of tree stems into logs in a way that maximises the recovery of useful wood
- Winching of logs to planned skid trails and ensuring that skidding machines remain on the trails at all times
- Adequate supervision and control of operations
- Conducting a post-harvest assessment to provide feedback to the resource manager and logging crews and to evaluate the degree to which RIL guidelines were successfully applied

Benefits of RIL include:

- Fewer trees unnecessarily cut and better use of those cut, thus less waste
- Improved cross cutting meaning a higher recovery of volume per tree and thus per hectare
- More careful skidding also increases recovery of volume
- The number of seriously damaged residual trees can be more than halved
- The area disturbed by heavy machinery about halved
- Economic evaluations have generally been favourable.

Chainsaw milling and pit sawing
Chainsaw milling is the on-site conversion of logs into lumber using chainsaws. Techniques and equipment vary. Pit sawing where hand saws are used is the predecessor of chainsaw milling.

Operations tend to be small scale. There are advantages with chainsaw milling, e.g.:

- Does not require major investments
- Feasible in areas inaccessible to conventional harvesting
- It can be used for conversion of isolated trees and lower quality logs
- Equipment is less invasive than in conventional operations

A rule of thumb is that the chainsaw cylinder volume in cubic centimetres should greater than the log diameter in centimetres. Special chains are available for chainsaw milling and should be used. Three types of mills are produced. They are: rail mills, frame mills and carriage mills.

Freehand milling dominates in tropical forests. Recovery is low, typically 20 to 30 percent for freehand chainsaw, and around 50 percent with carriage mills. Reference to images and videos of chainsaw milling are found in the Cases section.

Wood and biomass for energy
Harvesting of biomass can be integrated into harvesting systems, be done independently. Biomass can be harvested from

Natural forest. This is done extensively in many developing countries. It common that parts of trees are harvested rather than entire trees.

Trees outside forests. Urban trees, roadside trees, hedges, scrub and trees in agroforestry constitute a major source of energy.

Planted forest. Planted forest supply almost 20 per cent of the world's woodfuel.

Harvesting residues. A large share (sometimes up to half) of trees harvested is left behind as residues. Much of this can be used as energy. This is fairly common practice in Scandinavia.

Salvage harvesting. Sick and dead trees in damaged stands can be removed and used for energy.

Thinning. Stems removed as part of pre-commercial thinning and other unmerchantable trees can be used for energy.

Equipment and machinery

Common types of machinery are presented below. Readers who watch the images and videos suggested in the cases section should keep in mind that much of the material is from manufacturers. Opinions expressed are those of the video producers, not those of FAO.

Feller-bunchers

Wheeled or track mounted machines designed fell and bunch trees to be skidded, forwarded, or processed. Some felling heads are capable of handling trees of up to 75 cm. There is two general types. (1) Those with a hydraulically powered articulated swivel boom that sever, lift and swing the trees to the desired direction. (2) Short wheel base machines with close coupled holding arms and shear heads, and depend on moving and swinging the entire machine to perform the bunching function.

Processors and harvesters

A processor delimbs trees and crosscuts them into logs.

A harvester is a machine that fells, delimbs and cross cuts trees at the stump. There are wheeled as well as tracked carriages. Boom reach is typically about 10 m.

Draught animals and agricultural tractors

Draught animals can be used for smaller logs from final felling operations and from thinnings in manmade forests. Animals used include mules, oxen, water buffaloes and elephants.

The farm tractor can be equipped both skidding and forwarding, and also as a base machine for processors and simple harvesters. Farm tractors are common in plantation forestry.

Skidders

Skidders are self-propelled machines for dragging trees or logs by means of winch rope, chokers, grapples or clambunks. Skidders can be rubber tired or tracked. Tracked skidders are either rigid track skidders (crawler tractors/bulldozers) or flexi track skidders.

Forwarders

These are machines that transport trees or logs by carrying them on the chassis completely off the ground. Logs/trees are typically loaded and unloaded using hydraulic or mechanical cranes.

Machinery for log loading and shovel logging

Logs might be loaded on to trucks by truck mounted cranes (self-loading trucks) or by a separate loading machine. This can be a front end loader, a wheeled or tracked machine with forks, lifts or grapples attached to lifting arms at the front end, or a hydraulic loader. Logs may also be loaded manually or by means of simple winch systems.

In shovel logging log loaders are used to swing logs to the forest road. The loader moves across the harvest area, grabbing logs/trees within reach, and swinging them around to drop them closer to the road until they are at roadside.

Cable yarders, spars and carriages

A cable yarder is a machine on which is mounted a system of winches that are used to convey logs from the felling area to the landing in a cable yarding system. A spar is a standing or raised tree or steel tower used to provide lift for rigging in cable yarding. A carriage is a wheeled assembly that moves back and forth on the cable while suspended above the ground. Logs are attached to the carriage by a skidding line for yarding.

Further learning

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Credits

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