A simple planning system for sustainable timber harvesting in Papua New Guinea

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Abstract

Planning and management of forest resources in Papua New Guinea (PNG) has sometimes resulted in overcutting, resource depletion, unintended environmental impacts and uncertainty about the long-term capacity of forests to supply the future needs of local communities or industry. Sound inventory and planning are critical for sustainable forest management. Good systems are in place in PNG to determine forest area, forest inventory and future forest growth. However, they have not been integrated effectively for strategic forest planning. This paper describes some simple tools for integrating this information to provide more robust estimates of future timber yields and more realistic levels of annual allowable cut. It allows for assumptions relating to available forest area and harvest intensity to be explicitly presented and assessed by those approving forest operations. The system is scalable and could be applied to smaller areas under community management, larger timber-harvesting operations or national-level analysis. The operation of the system is demonstrated through application to a case study area in Madang province. Some of the challenges, constraints and desired improvements to the system are discussed. Forest planning is not a linear or static exercise. Plans for long projects covering large areas must be periodically reviewed to incorporate new information, changing standards and changing community expectations.

Introduction

The forests of Papua New Guinea (PNG) are among the world's most complex natural resource management challenges. With 33 million hectares of tropical forest, PNG has the third-largest expanse of tropical forests in the world. These forests are complex in composition, structure and function. PNG society is also complex. The population of 5 million has over 800 language groups and a wide diversity of social and land-ownership arrangements. Almost all forests are under customary ownership by local clans or individuals. Forests are of major importance for the livelihoods of rural communities, providing construction materials, food, medicines, clean water and other non-timber products to local communities, They are sometimes also used on a rotational basis for gardening. Forests are often the only source of cash income for many communities for education and health services. For the global community, PNG forests have significant value for conservation of tropical forest biodiversity and carbon storage.

Planning and management of forest resources has sometimes resulted in overcutting, resource depletion, unintended environmental impacts and uncertainty about the long-term capacity of forests to supply the future needs of local communities or industry. Development and use of forest resources is seen by most sectors of the community as an integral

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component of national development, but accommodating diverse community interests in planning forest development is a significant challenge.

This paper provides an overview of forest-management planning, presents information on the planning and inventory systems in PNG, and describes the development and application of a simple harvest-planning tool that can enable better decision-making in setting allowable cuts for timber harvesting from forests in PNG. It was developed as part of a project that aimed to build capacity and knowledge within PNG for forest inventory, and planning and analysis of alternative options for timber harvesting. The project focused on improving capacity for strategic-level planning, particularly for inventory, assessment and predicting the supply of timber resources.

Forest-management planning

Forest-management planning involves:

- setting objectives for the forest-management unit
- specifying management actions (e.g. harvesting, regeneration, fire control) to be undertaken in the forest to meet those objectives
- implementing actions
- reviewing outcomes and revising plans.

Objectives for strategic plans are generally developed by forest owners and managers in consultation with those in the community who will be affected by the activities.

Planning is considered an essential component of sustainable forest management. Plans demonstrate that forest managers have taken into account the full range of forest uses, products and values in determining the management of forest resources. Ideally, strategic plans should be reviewed regularly (every 5 years) to ensure that they continue to reflect community requirements and new information.

Management to produce a sustained yield of products or services can be achieved in a number of ways. Historical concepts of sustained yield from forests have generally been based on production of timber from even-aged forest stands in an estate with a balanced set of age classes, such as might be established in developing a forest plantation area.

Natural tropical forests are usually managed on a selection system. In this case the goal is to maintain a balance of tree age and size classes across the area under management. In a forest that has had no previous harvesting, there is usually a high proportion of trees of larger size classes.

In these types of forests, the first cutting cycle will generally result in higher levels of production than that which can be achieved under ongoing management of the remaining forest. This cut is also based on a forest with a high proportion of larger trees, and will produce a very different kind of resource in terms of log size to that from second and subsequent harvests, which will be based on smaller regrowth trees. A policy or management decision is therefore often required to determine the length of time over which this first cut will occur. This will be determined by the market and the desires of the forest owners.

PNG forest policy and planning

The 1991 PNG National Forest Policy was prepared to remedy the shortcomings of the previous 1979 policy and to accommodate the recommendations of the Barnett Forest Industry Inquiry (1987). The policy was endorsed in 1990 by the National Executive and was followed by a new Forestry Act being passed by Parliament in 1991.

The policy sets out objectives for the management and protection of the nation's forest resources as a renewable natural asset, and to utilise them to achieve economic growth, employment creation, greater PNG participation in industry and increased viable onshore processing. Forests are to be identified and classified as production, protection, reserve or salvage forests, or land suitable for afforestation under the policy.

PNG has detailed legislation covering forest planning and management in the Forestry Act 1991 and amendments in 1993. Later amendments in 1996 mainly related to changes in the composition and selection of the Board. In addition, harvesting operations are covered under the Key Standards for Selection Logging in Papua New Guinea and the Papua New Guinea Logging Code of Practice (1996).

The National Forest Policy and planning arrangements in PNG are largely directed at providing the policy and regulatory framework for producing timber rather than providing for the full suite of products, values and services encompassed by sustainable forest management (Hammond 1997). However, in establishing an appropriate level of timber supply, the forest planning process needs to take account of these other values. Historically, resource-level information has been used to schedule the production of timber. Recently, forest-management systems have been devised to consider an appropriate balance between competing values (Ferguson 1996).

Natural forests in PNG have high species diversity, and only a relatively small proportion of species has timber properties suited for wood products. Silvicultural prescriptions are relatively rudimentary, and timber-harvesting operations are based on selective harvesting with a simple size limit restriction of 50 cm diameter at breast height (DBH).

Sustained yield management is set out as the guiding principle for forests classified as production forest. The National Forest Policy states that:

> The National Forest Plan shall designate the potential of each province and be based on a National Forest Inventory of commercial forest resources complied and updated on a province by province basis. …The allowable cut will be set initially by dividing the total merchantable resource within the production forest by an assumed cutting cycle of 40 years.

The plan sets out fairly general strategies for inventories designed to estimate the volume and quality of the forest resources. The policy sets an ambitious target—to undertake a rapid resource appraisal within 1 year, as described by Hammermaster and Saunders (1995).

Other requirements for forest planning and inventory in PNG are specified in the Forestry Act and in planning, monitoring and control procedures. For large areas such as Forest Management Areas (FMAs) in PNG, plans are generally developed at three levels: strategic (20–40 years), tactical (5–10 years) and operational (1 year) (Figure 1).

A major problem with setting the annual allowable cut (AAC) for FMAs has been that operations that are intended to last for 35–40 years (and then provide for a future harvest at a similar level) have often only lasted 10–15 years.

Some of the reasons for this emerged during a review of planning and inventory, where the following issues were raised by government and research participants:

- The National Forest Policy states that all agreements and permits will be conditional upon broad land-use plans, but there is currently no comprehensive land-use planning process in place in PNG.
- Road access is a major factor in resource planning. Roads serve different functions besides timber extraction; for example, for agriculture and other access to towns and villages. At present there is no general infrastructure plan within which access for timber harvesting can be considered.
- Inventory requirements for tactical and operational planning are too demanding. The industry operator can decide what is required for operational purposes.
- Estimation of the available area is based on simplistic assumptions that do not adequately take into account accessibility, protection of watershed values, slope restrictions, conservation or community values (Table 1).
- There is no process for review of the AAC during the life of a project to take into account the rate of harvesting or new information on the FMA.

The 'net harvestable area' can be difficult to estimate in the context of selection harvesting systems and uneven aged stands, and has been the cause of major discrepancies between predicted and realised harvest volumes in Australia and other places (FAO 1998; Whiteley 1999).

Determining the precise boundary of the net harvestable area may be difficult, especially in broken terrain where harvesting is limited by slope in an irregular way, or where the quality of forest is marginal and only selected areas or patches are suitable for harvesting. By definition, the net harvestable area is the area remaining after eliminating various exclusion areas. Exclusions relate to the following:

- riparian strips, corridors and other units set aside from harvesting for whatever reason (environmental, cultural or scientific purposes)

Figure 1. Forest planning requirements under the Forestry Act 1991

Table 1. Reasons why native-forest timber resources are cut much sooner than planned—results from discussions at a workshop in Papua New Guinea, May 2003

AVAILABLE FOREST AREA OVERESTIMATED
• Overestimating the total forest area (i.e. mapped forest areas that have been converted to other land cover) • Accessibility not adequately determined (e.g. effects of steep slopes, difficult soils, inundation) • Roading access not known at inventory—may reduce areas that are economic to road access due to low volumes and/or high roading costs • Conservation requirements not adequately met • Impact of Code of Logging Practice not adequately addressed (e.g. stream buffers, slope or other restrictions) • Village cultural/gardening requirements need to be quantitatively evaluated • Landowner intentions may be unclear or change • Excessive snigging distance may reduce area availability due to uneconomic haulage
AVAILABLE TIMBER VOLUME PER HECTARE OVERESTIMATED
• Inventory design may be inadequate or biased • Inventory may be out of date or not current • Timber quality may have been degraded through fire, disease or other disturbance (e.g. 1997 drought and fires) • Inventory used different log standards to those applied by industry (e.g. 50 cm DBH limit used for inventory but some companies harvest only above 60 cm) • Industry uses a more limited number of species to those assessed • Industry uses different standards for log length or defects to those in the inventory • Potential bias in tree volume equations

- areas deemed too steep to harvest using prevailing systems
- larger patches of forest containing insufficient timber to support a harvesting operation for the target products.

The physical area of disturbance in a selection harvesting system comprises the immediate area of trees damaged by felling single trees or small groups of trees (typically 3–20 trees per hectare in PNG), and associated snig tracks, roads and loading areas. Patches of disturbance are separated by small areas of more-or-less undisturbed forest, often containing trees less than the merchantable size limit for harvesting plus both large and small non-commercial trees. This mosaic of disturbed and undisturbed forest together defines the net harvestable area.

In the context of broad-scale inventory (as required at the FMA scale), it is neither practical nor efficient to prepare detailed net area maps for a surveyed area. What is required is that the sampling system used to collect volume information also provides an independent estimate of the netting factor that should be applied to the gross area sampled to allow realistic estimates of both loggable area and volume to be generated.

Analysis of available area using alternatives to the simple assumptions being applied in PNG indicated that these could reduce the area of forest available for harvesting by more than 50% (Table 2), with increased reductions in area available during second and subsequent harvests.

The fundamental requirements for a production forest-management planning system include:

1. a statement of the area of forest in different age, forest type and/or productivity classes, accessibility criteria, riparian zone, priority protection, community use and other constraints on timber production
2. an inventory of forest timber and other values
3. a growth model to estimate the projected yield of timber volume or mass over time; for uneven-aged forests, this model should reflect the effect on forest growth of different intensities of harvesting
4. a system for integrating forest area, inventory and growth modelling, and projecting the effects of different harvesting regimes on forest composition and structure.

Planning system and yield calculation

Harvest levels can be set using area or volume control. In its simplest form, area control divides the forest area by the cutting cycle to determine an area to be harvested each year. Volume control determines the harvest volume based on an estimate of the current timber volume, stand increment following harvesting, and desired production to meet industry or community needs. Currently, PNG harvest planning is based on volume control; that is, an annual allowable cut is set based on the strategic inventory.

It has been argued that planning should shift to area control, with industry permitted to cut only a given area of forest each year. Chatterton et al. (2000) suggested that, instead of the Papua New Guinea Forest Authority (PNGFA) committing to an AAC statement in the tender call, it provide a commitment that the final net area agreed for harvesting will be made available under the terms of the Papua New Guinea Logging Code of Practice (1996), as amended from time to time. The project would be divided into a number of coupes depending on the size of the overall project; irrespective of the volume, a successful tenderer would be restricted to operating no more than 6/40 of the gross area in any 5-year period.

These different types of planning and control methods have advantages and disadvantages (Table 3). The most effective approach to meet the needs of industry and ensure that harvesting lasts the intended cycle is to use volume control and review the annual cut periodically (e.g. every 5 years), based on records of the volume removed and the area harvested. These volumes per hectare can be used to recalculate the remaining volume in the project area. This is divided by the number of years remaining in the cycle to set a new allowable cut level.

Table 2. Reductions in area available for harvesting associated with different factors based on analysis of land tenure, topographic maps, data from the Forest Information and Management System—example is for the middle Ramu Forest Management Area in Madang province, Papua New Guinea

	Area (ha)	Percentage
Gross forest area	156,600	
Exclusions from 1st cycle		
• Conservation reserve	31,570	20.2
• Slope outside conservation	14,490	9.3
• Altitude outside conservation		
• Inundation outside conservation		
• Fragile	3,598	2.3
• Streamline buffers not in above	17,135	10.9
• Community reserves not in above	5,875	3.8
• Other inaccessible	259	0.2
1st cycle net area	83,673	53.4
Additional exclusions after 1st cycle		
• Conversion to gardens	10,400	12.4
• Regrowth area reduction	4,184	5.0
• Roading	4,184	5.0
• Other	3,887	4.7
2nd and 3rd cycles net area	61,018	39.0

Table 3. Advantages and disadvantages of area versus volume control of timber harvesting in a variable native forest—results from a workshop held in Papua New Guinea, May 2003

	Area control	Volume control
Advantages	• Harvesting lasts full cycle • Accurate inventory less important	• Consistent annual cut (while this lasts) • Allows for industry requirements in species and size classes
Disadvantages	• Highly variable annual harvest • Industry must accept species in the area	• Cut may not last full cycle • Depends on accurate inventory estimates

Methodology

A simple spreadsheet harvest-planning tool

The project developed a simple spreadsheet planning system to provide a sound basis for forest-harvest planning by volume control. The tool facilitated the integration of forest area, inventory and growth information to calculate timber yields under different management scenarios. The tool was developed using Microsoft® Excel software. It provides a simple system for integrating data and a basis for analysis of alternative cutting strategies.

The input and output pages of the tool are shown in Figures 2 and 3. The user enters data on forest inventory, growth and yield (Figure 2). These are divided into nine different species quality groups and size classes so that the allowable cut can also be separated into these different categories. The user indicates the preharvest data, ingrowth, upgrowth (those trees moving from one size class to the next) and proportion of volume lost each year due to mortality and harvesting damage.

Area information for a forest-management unit is input by the user (Figure 3). The main factors that reduce available forest area (conservation reserves, altitude, inundation, fragile soils) are those contained in the Forest Management and Information System. Provision can also be made for stream buffers and community reserves. This 'discounting' of the gross forest area needs be done in a systematic way so that double counting does not occur.

Estimation of the area available for cutting in second and subsequent cycles needs to consider additional factors such as the area permanently lost to roads, to gardens or other agriculture that enters the regrowth/fallow cycle, and to impacts of landings and skid tracks. These estimates are entered as percentages.

The system assumes a standard volume per hectare across the area for which timber production is considered. Once area and volume data are entered, the user can enter a cutting cycle length in years (Figure 2), and a proportion of each minimum export price (MEP) code and size class that will be harvested in each cycle.

The system then calculates the annual yield based on the harvesting strategy and the available area (Figure 3). This can be used to set the level of the allowable cut. The user can also enter a value figure and a discount rate, and the system provides an assessment of net present value.

Output from this system can be used to assess the implications of alternative management options. For example, a heavy cut of all trees greater than 50 cm DBH (similar to current log-export operations) will result in a high yield (170,000 m^3/year) in the first cutting cycle of 35 years, but a dramatic decline in second and third cycles to less than 50,000 m^3/year (Figure 4a). If the cut is restricted to trees in MEP codes 1, 2, 3 and 6, and trees greater than 65 cm DBH (specifications used by some local processors), yield will decline to 130,000 m^3/year in the first cycle and to about 20,000 m^3/year in the second and subsequent cycles (Figure 4b).

Adopting a management regime that leaves a proportion of currently commercial trees (particularly those of 50–65 cm DBH) for future cycles can result in a longer term, uniform flow of wood of about 50,000 m^3/year (Figure 4c).

Discussion

Large-scale timber-harvesting operations of native forest in PNG have generally not been managed in a way that maintains an ongoing flow of timber and other benefits to the local landowner groups. While the specified cutting cycle of 35–40 years is intended to provide the basis for a continuing forest operation in areas under FMAs, this has not generally been the case, with the harvest levels set for most operations leading to the depletion of the merchantable forest within 10–20 years. This is due to overestimation of the available forest area and the merchantable volume, and flawed assumptions in the calculation of the allowable cut.

The simple harvest-planning system presented here provides an improved basis for estimating the yield associated with different types of harvesting operations, and for establishing the annual allowable cut. It allows for assumptions relating to available forest area and harvest intensity to be explicitly presented and assessed by those approving forest operations. The system is scalable and could be applied to smaller areas under community management, larger operations or even a national-level analysis.

A key challenge in implementing the system is having robust information on the following:

- standing volume based on an unbiased systematic or random sample of the forest area under consideration (see Brack 2011)
- information on recruitment and forest growth after harvesting
- the impacts of harvesting and other factors on stand mortality

- the current forest area and the extent of area that might be unavailable due to slope, access, conservation reserve, village use or other constraints
- the extent of future impacts such as fire, gardening and conversion to agriculture.

These will vary considerably with the region, location, topography and size of the harvesting area, and with accessibility factors such as proximity to all-weather roads.

As indicated earlier, for a native forest area that has not previously been subject to harvest, the level of the initial cut and the period over which it occurs is a management decision. It will be determined by factors such as the minimum level of harvest to justify the development of infrastructure such as roads or ports, and the resource required to support the establishment of a processing facility. A 'non-declining, even flow' of timber (e.g. Figure 4c) is often seen as the most desirable goal of management for timber harvest. However, this does not have to be the case, and alternative options resulting in a 'fall-down' to a longer term sustained yield based on harvesting of

Figure 2. Simple harvest planning tool developed using Microsoft® Excel software—section showing the timber inventory by size class and tree species quality (MEP code). User defines the cut fraction in each class and provides estimates of growth, mortality or damage. Data are for the middle Ramu Forest Management Area in Madang province.

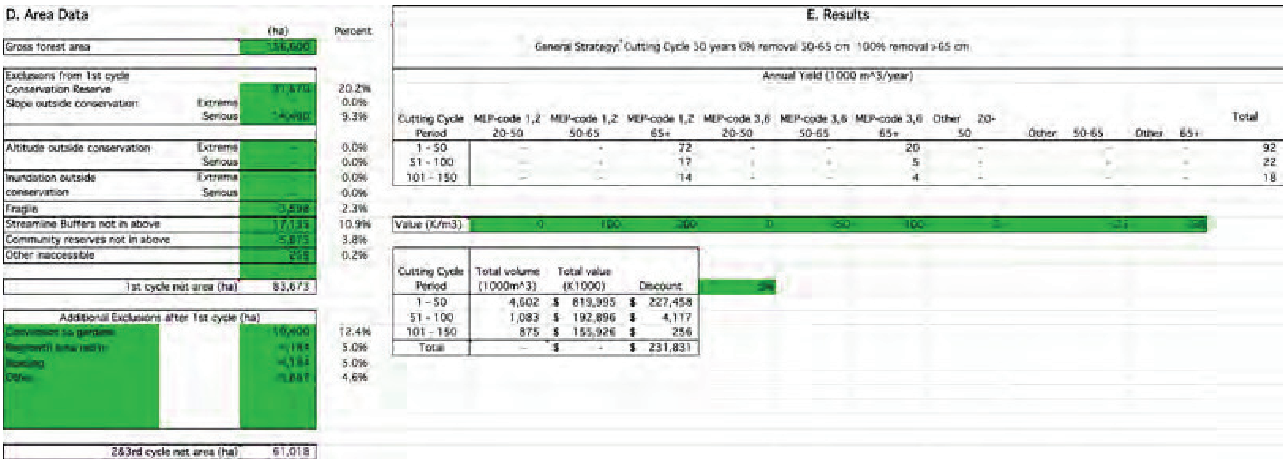

Figure 3. Simple harvest planning tool using Microsoft® Excel software—section showing the planning unit area data, area exclusions in first and subsequent cutting cycles, timber yield and total volume, and value information. Data are for the middle Ramu Forest Management Area in Madang province.

regrowth forest may be a legitimate and sustainable forest-management approach, provided that other values (e.g. water, biodiversity, cultural or subsistence benefits) are properly provided for.

The system could be improved by linking it to a growth model that projects stand structure from current inventory, based on growth functions determined from sound data on forest growth. This could also be used to provide information on likely stand structure (tree size distribution and composition remaining after harvesting), and could be compared with post-harvest inventory data. If these data were available, the system would be updated and re-run on a regular basis in order to review the allowable cut based on harvest yield information and assessment of future available volume.

Conclusions

Planning and management of forest resources in PNG have sometimes resulted in overcutting, resource depletion, unintended environmental impacts and uncertainty about the long-term capacity of forests to supply the future needs of local communities or industry.

Sound inventory and planning are critical for sustainable forest management. Good systems are in place in PNG to determine forest area, forest inventory and future forest growth. However, they have not been integrated effectively for strategic forest planning. Area and inventory systems need to be regularly updated to reflect harvesting and other disturbances, changes to policies and codes of practice, and changing industry log standards. More inventory

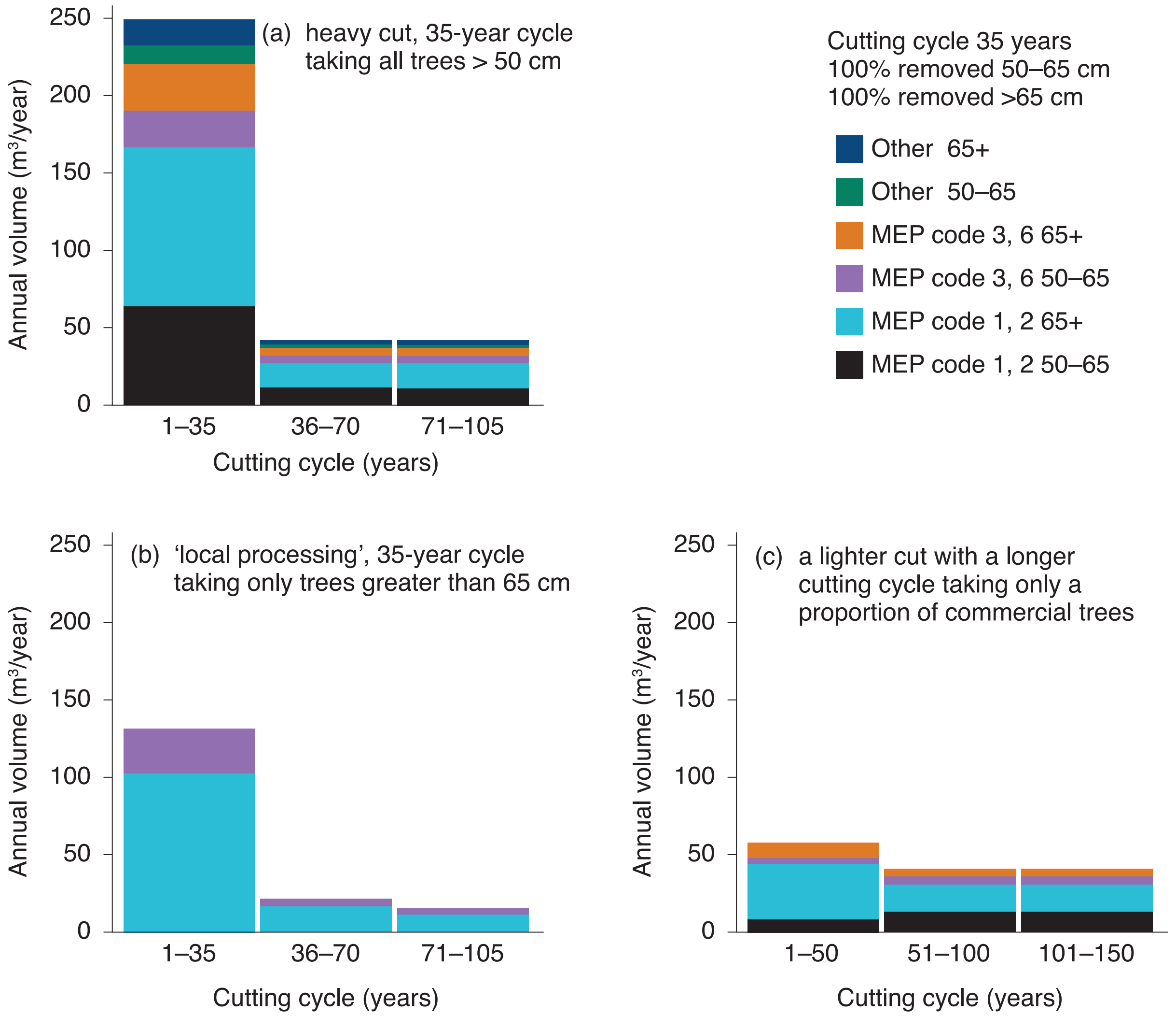

Figure 4. Management simulations using the simple harvest planning tool for the middle Ramu Forest Management Area in Madang province, Papua New Guinea. Estimated available forest area in each case is 84,000 ha. MEP codes 1 and 2 are higher quality timber species, MEP codes 3 and 6 are lower quality species, and 'other' is other merchantable species.

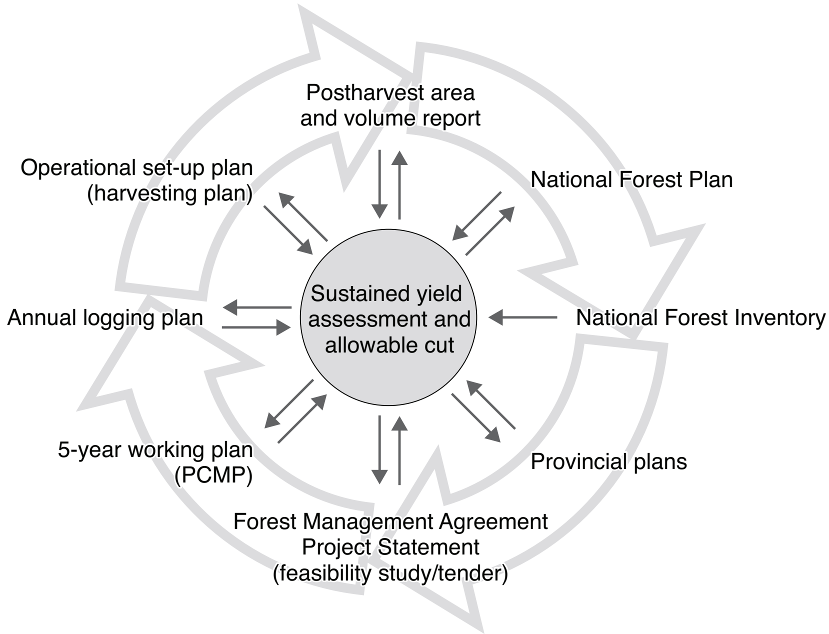

Figure 5. An 'adaptive management' model for forest planning in Papua New Guinea that links forest assessment and planning at different scales

effort should be put into postharvest assessment. This will provide more-valuable information for strategic planning and future management. Permanent sample plots need to be maintained and remeasured to provide sound information on the growth of cutover forests.

Application of simple calculation tools can ensure that forest inventory, growth and area information are effectively integrated to provide more robust estimates of future timber yields in order to set more realistic levels of annual allowable cut.

Forest planning is not a linear or static exercise. Plans for long projects covering large areas must be periodically reviewed to incorporate new information, changing standards and changing community expectations (Figure 5).

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