Management of natural tropical forests in the past and present and projections for the future

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Abstract: Considering the increasing areas covered by tropical disturbed forests, it is clear that future conservation of biodiversity and tropical forest ecosystems will mostly take place within what we call here "anthropogenic" forests, and only if they are well-managed. The term "well-managed" means that the elastic capacity of a specific forest type is respected and the rules for logging and other forest use practices must be established to guarantee the perpetuation of forests in good conditions so that they provide all the services desired by society. Hence, tropical silviculture will have to play a major role in the future to ensure sustained and sustainable production of forest products. The first part of this chapter presents the concept of SFM of tropical forests, and the silvicultural practices to be implemented in the future in managed production forests. The second part discusses the diversity of actors involved in the management of tropical forests and the need to include these actors in SFM in the tropics. The third part reviews the shortcomings of current policies and discusses the move towards more integrated management perspectives as well as multi-level forest governance approaches. The last part examines the role of forest policies in promoting SFM in the tropics, taking into account the changing perception of sustainability, the technical constraints of tropical silviculture, and the need to involve multiple actors.

Keywords: Tropical silviculture, sustainable management of tropical forests, tropical managed forests, tropical forest policy

2.1 Introduction

Forests cover about 4 billion ha worldwide, representing 31% of the total land area on earth and 7% of the earth's surface (FAO 2010). Although the rate of deforestation has decreased during the past decade, forests still disappear at an alarming rate, particularly in tropical regions (FAO 2012, Figures IV 2.1 and IV 2.2). About 13 million ha per year were converted to other uses or lost through natural causes between 2000 and 2010, compared with 16 million ha per year in the 1990s (FAO 2010, 2012). After massive deforestation for several centuries, most developed countries experienced a transition from net forest cover decline to net forest cover increase 100 years ago or even earlier (Figure IV 2.1, Rudel et al. 2005). As a result, European countries now have more forests than they had 100 years ago (FAO 2012). Presently, forest cover in Europe consists mainly of planted and naturally guided regenerating forests often managed as production forests, which are quite different from the original (primary) forests of these countries. In contrast, tropical forests were still largely intact until about the mid-20th century and since have decreased dramatically (Figure IV 2.2). Tropical forests are mainly impacted by advancing cash crops such as oil palm and soybean, cattle ranching, and in certain cases, small-scale agriculture. At present, natural tropical forests amount to about 50% of the world's forests, are home to more than two-thirds of terrestrial living species, and contain the highest terrestrial biodiversity on earth. Blaser et al. (2011) estimated that about 50% of tropical forests are still primary forests, while only 36% of the world's forests are primary and only 12% are included in legally protected areas (FAO 2010).

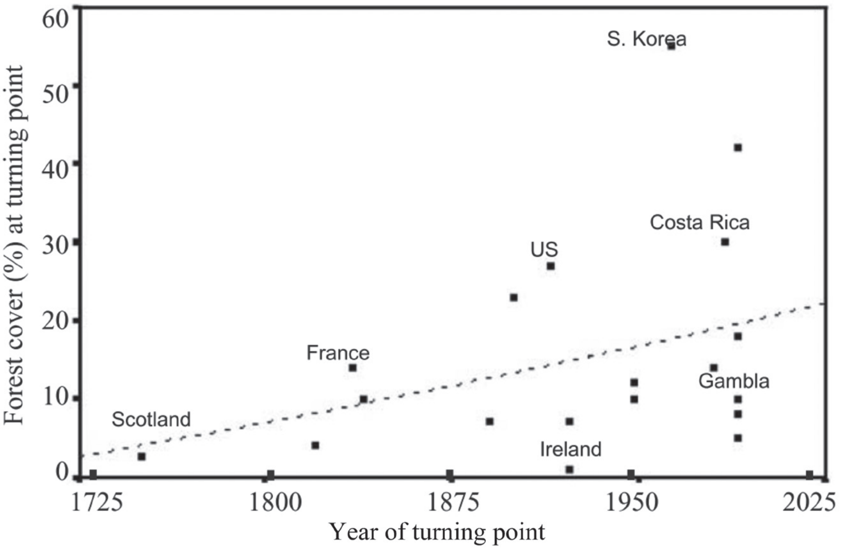

Figure IV 2.1 Forest cover at turning point in different countries which already started forest transition. Source: Rudel et al. 2005

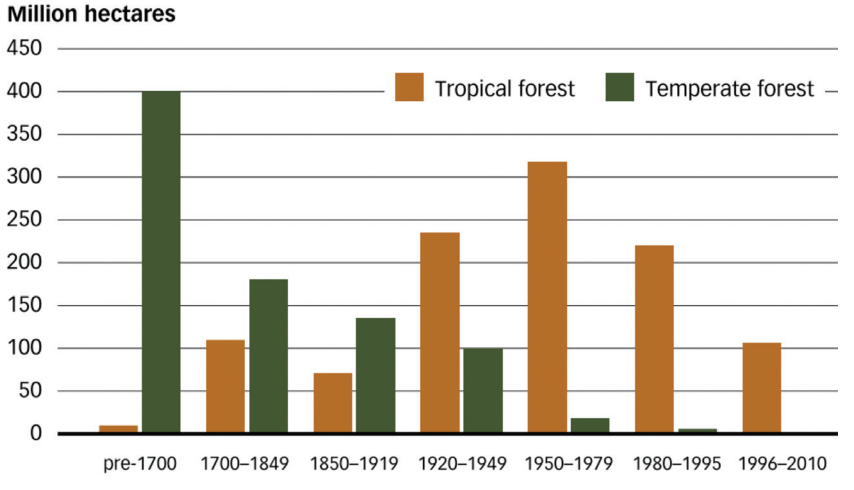

Figure IV 2.2 Change in forest cover in the tropics and temperate regions. Source: FAO 2012

The conservation of tropical forests is, without doubt, one of the main challenges of this century, but areas established for forest conservation will not be able to ensure the conservation of all species (Nasi and Frost 2009).

However, considering the increasing areas covered by tropical disturbed forests, it is clear that future conservation of biodiversity and forest ecosystems will mostly take place within what we call here "anthropogenic" forests, and only if they are well-managed. The term "well-managed" means that the elastic capacity of a specific forest type is respected[(1)] and the rules for logging and other forest use practices must be established to guarantee the perpetuation of forests in good conditions so that they provide all the services desired by society.

Hence, tropical silviculture will have to play a major role in the future to ensure sustained and sustainable production of forest products (Peña-Claros et al. 2008, Villegas et al. 2009). Silviculture is defined here as "the art and science of producing and tending forests by manipulating their establishment, species composition, structure, and dynamics to fulfil given management objectives" (ITTO 2002).

[(1)] Elastic capacity of a forest ecosystem: forest management needs to take into account the dynamic processes of a forest within a range of changing vertical forest structure, species composition and biodiversity, and productivity that is normally associated with the natural forest type expected at a specific site.

Although, sustainable forest management (SFM) is considered by the forest sector to be synonymous with good forestry, forestry and forest management are commonly perceived negatively by many forest ecologists, conservationists, and society in general. This perception is largely a result of bad forestry practices such as extraction of excessive amounts of timber and fuelwood and illegal logging, very common in the past and still quite common in tropical forests. However, even excessively logged forests can retain high biodiversity and stored carbon (Berry et al. 2010, Putz et al. 2012). Silvicultural practices that are part of overall good forest management are likely to be efficient tools to conserve large areas of production forests that provide multiple forest functions. Tropical forest academics generally defend silviculture as a tool that helps effective conservation of tropical forests while enhancing the production of timber or other products. Forest ecologists and conservationists, on the other hand, argue for biodiversity conservation in protected areas or the promotion of community forest management, which is widely considered to have less impact on tropical forests (Gibson et al. 2011, Putz et al. 2012, Sist et al. 2012, Zimmerman and Kormos 2012a, Zimmerman and Kormos 2012b).

This chapter has four parts. Part one considers the concept of SFM of tropical forests, focusing on the trends previously mentioned, and on silvicultural practices to be implemented in managed production forests. The second part discusses the diversity of actors involved in the management of tropical forests and the need to include these actors in SFM in the tropics. The third part reviews the shortcomings of current policies and discusses the move towards more integrated management perspectives as well as multi-level forest governance approaches. The last part examines the role of forest policies in promoting SFM in the tropics, taking into account the changing perception of sustainability, the technical constraints of tropical silviculture, and the need to involve multiple actors.

2.2 Modern tropical silviculture: Towards new concepts of sustainability

2.2.1 The concept of sustainability

One of the most accepted definitions of SFM is that of ITTO (2005): "The process of managing permanent forest land to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction in its inherent values and future productivity and without undue undesirable effects on the physical and social environment." SFM's goal is not only to ensure the flow of goods and services but also to maintain forest processes intact, including keeping the array of functional species that provide those goods and services (Thompson et al. 2009). SFM considers forests in both time and space. Hence, SFM represents a balance between conservation and the production of forest goods and services for humans and must operate within the capacity of the forest to recover and maintain its functions. For the World Commission on Forests and Sustainable Development (1999), SFM "must be a flexible concept that accepts changes in the mix of goods and services produced or preserved over long periods of time and according to changing values signaled by various stakeholder groups" and that SFM "should be viewed as a process that can be constantly adapted according to changing values, resources, institutions, and technologies."

Tropical forest management until recently focused mostly on timber production, with the principal objective being sustainable timber yield. The central approach was logging of trees above a minimum diameter size and subsequently allowing the tree stock to recover for a period of between 30 and 40 years. The crucial question for foresters for many years was, therefore, how much does the timber stock increase during a rotation cycle between 30 and 40 years. Under this view of forest management, sustainability is reached if at each logging cycle the same volume of timber is extracted as will be recuperated over the next 30 to 40 years.

However, silviculture is certainly not limited to developing practices just to promote timber yield. Silviculture must be regarded as the practice of controlling the establishment, growth, composition, health, and quality of forests to meet diverse needs that are previously defined in the management plan. Silvicultural practice consists of the various treatments that may be applied to forest stands to maintain and enhance their utility for the purposes defined in the management plan (Smith 1986). Finally, silviculture must also ensure the long-term continuity of essential ecologic functions, and the health and productivity of forested ecosystems (Nyland 1996). Under these considerations, silviculture is primarily a tool to both achieve sustainable production of goods and maintain the environmental services provided by forest ecosystems.

Most of tropical forest biologists, ecologists, and conservationists have a somewhat different view of SFM. In their view, it requires the return to the conditions before logging by the end of the rotation cycle. This implies that the forests should exhibit the same structure, the same timber volume and the same species diversity, biomass, and ecological processes as before the logging operation. Studies looking at the

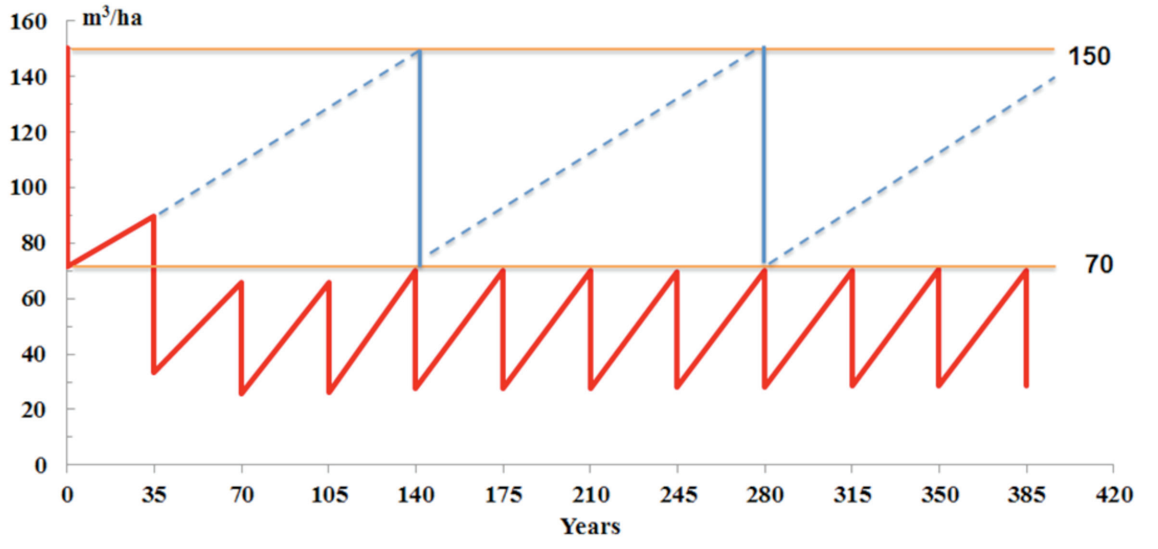

Figure IV 2.3 Sustainable extracted timber volume at each rotation cycle of 35 years (red line) and at cycles of 100 % timber volume reconstitution (blue lines) in a mixed dipterocarp forest of East Borneo. Source: Sist et al. 2003

impact of logging on the recovery of some of these variables (timber volume, biomass, and tree species diversity) in tropical forests, however, demonstrate that within a rotation cycle of 30 to 40 years, only 50% of the initial timber volume can be recovered (Putz et al. 2012). For example, in Southeast Asia, simulations of post-logging forest dynamics suggest that a rotation cycle of 40 years yielded harvestable timber of 60 m^3/ha, while the first felling in primary forest yielded 87 m^3/ha (Sist et al. 2003, Figure IV 2.3).

Logging intensity has been largely recognised as the main factor determining the forest's capacity for timber reconstitution and biomass in tropical forests (Sist et al. 2003, Putz et al. 2008). Even when reduced-impact logging techniques are used (see Putz et al. 2008 for details on RIL techniques), several studies seriously question the forest's capacity to recover both timber volume and biomass within the length of the rotation cycle (Dauber et al. 2005, Zarin et al. 2007). The silvicultural management of tropical humid (primary) forests is complex. Primary forests regenerate in small patches (gaps) and thus are ecologically multifaceted. Thus the first logging interventions in such complex ecosystems are decisive with respect to the destiny of these forests. Although under sustainable practices these managed forests are likely to remain very close to primary forests, they will undoubtedly present differences in their structure and species composition.

Logging intensity plays also a major role in the reconstitution of biomass. For example, Mazzei et al. (2010) show that, in the Amazon, with a logging intensity of three trees/ha the pre-logging biomass would recover after 15 years while under higher felling intensities of six trees/ha and nine trees/ha, biomass recovery would take 51 and 88 years, respectively. Regionally, forest structure (Paoli et al. 2008, Quesada et al. 2012) and species composition (Condit et al. 2002, ter Steege et al. 2013) can vary significantly due to soil and climate variations (e.g. Amazon basin, Congo basin), affecting biomass stocks and dynamics (Malhi et al. 2004, Slik et al. 2010). The capacity of a forest to recover its initial timber volume and biomass is therefore likely to be influenced by these variations in dynamics (Sist et al. 2011).

2.2.2 Silviculture as a tool for conservation

Achieving sustainable timber production was the dominant focus for a long time. However, when societal demands on forests changed and began to include, for instance, contributing to rural livelihoods, satisfying recreation needs, and providing ecosystem services, sustainable timber production became too narrow a focus. Forests produce much more than just timber and the forest products and benefits are of interest to many more actors than logging companies only (Nasi and Frost 2009). New societal demands resulted in the replacement of sustainable timber production with the concept of multiple-use forestry, which encompasses production of different goods (timber, non-timber forest products) as well as services (environmental, scenic, conservation) (Guariguata et al. 2012).

Tropical primary forests exhibit particular features that should be taken into account when logging them, including:

- Existence of emergent trees that are the preferred target of logging in primary forests, particularly in the first cut. However, as these trees have grown over long periods of time, they will not be part of consecutive cutting cycles in a managed forest.
- Great variety of sites and forest types with different structures and composition. The variety of tree species is enormous, making silvicultural planning complex and challenging.
- Most of the (commercially) interesting species occur in small numbers, thus single-tree mixture generally dominates.
- In all tropical forest types, however, there are so-called horizontally and vertically continuous tree species that also occur with higher abundance. These species are of particular interest in silviculturally managed forests; but with few exceptions, they are not the preferred species from a commercial viewpoint.
- Only few tree species in humid tropical forests produce marketable wood in larger scales, with the exception of dipterocarp forests in Southeast Asia.

Many companies that hold forest concessions in Southeast Asia and South America will soon begin, or have already started, the second felling cycle. Forests being logged for a second time, 30 to 40 years after the first logging, are poorer than during the first logging cycle. The timber volume has not recovered its initial level and in many cases there are insufficient numbers of small and mid-sized trees that eventually should produce timber for a third logging cycle. The lack of future crop trees is partly linked to physiological reasons, as mid-sized trees are not necessarily younger than canopy-dominant trees but are losers in stand competition, and to the fact that these trees are often damaged from the first cut. In such cases, silvicultural treatments are of utmost importance and they need to adapt to the conditions of forests logged for a second time to ensure that these forests will be productive in the future. It may be necessary to increase the number of years in the rotation cycle because many of these forests have been logged more than once within the first rotation cycle. Conservation of these logged forests is essential for the future. Unfortunately, technical recommendations made by researchers to adapt harvesting practices to the regeneration capacities of valuable species are usually ignored not only by forest companies but also by sectoral agencies that develop forest regulations (Fredericksen and Putz 2003, Sist and Nascimento-Ferreira 2007, Peña-Claros et al. 2008). For example in dipterocarp forests of Kalimantan provinces (Indonesian parts of Borneo), where minimum diameter cutting limits of 60 cm and cutting cycles of 40 years could be applied (Sist et al. 2003), new regulations promoting a diameter cutting limit of 40 cm associated with line planting of fast-growing timber species and cycles of 25 years are now implemented in areas logged only 20 years ago. These new technical recommendations are incompatible with the concept of sustainable timber production and will undoubtedly lead to the ultimate impoverishment of these production forests within a short time, causing their eventual replacement with short-term profitable tree plantations such as oil palm plantations.

Degraded and secondary forests are now the predominant forest types in many tropical countries. Degraded forests are "skimmed-off" primary forests in which timber, fuelwood, and other forest products have gradually been depleted. Depending on the intensity, what remains is either degraded primary forest or secondary growth. Secondary forests contain various stages of succession and are less heterogeneous within and between different sites, at least during the early pioneer stages. They are also less diverse. The dominant species in the early secondary stages are short-living pioneer trees that demand light. Over time, secondary forests become more diverse and shade-bearing species can install themselves (as long as the seed-disbursing vector is existent). The quantity of biomass can reach that of primary forests in the course of 100 years or more, depending on site conditions. Under good site conditions, secondary forests have a high capacity to sequester CO_2 and can become important carbon sinks. Most degradation is the result of unsustainable extraction of forest products and values. The area affected is estimated to be between 850 million ha (ITTO 2005) and 1.1 billion ha (WRI 1999). An exception to this is commercial selective logging in humid forests at short intervals, but this affects a smaller area in comparison with other forms of degradation.

We are now living in a world largely shaped by human activities (an era called the Anthropocene) and we are entering an era dominated by the above-mentioned logged-over forests and by agroforests, secondary forests, and "novel forests" (Lugo 2009, Lugo 2013). These novel forests are principally a mix of native and introduced plant and animal species, which is not incompatible with the regeneration of native species. In some areas, Puerto Rico being a well-documented example, these novel forests largely dominate the landscape and have naturalised over most of the geographic space (Martinuzzi et al. 2013). The novel forests are the results of past and present anthropogenic activities, essentially abandonment of agricultural land and naturalisation of exotic species. The area of novel ecosystems, (Hobbs et al. 2013) including novel forests, will increase

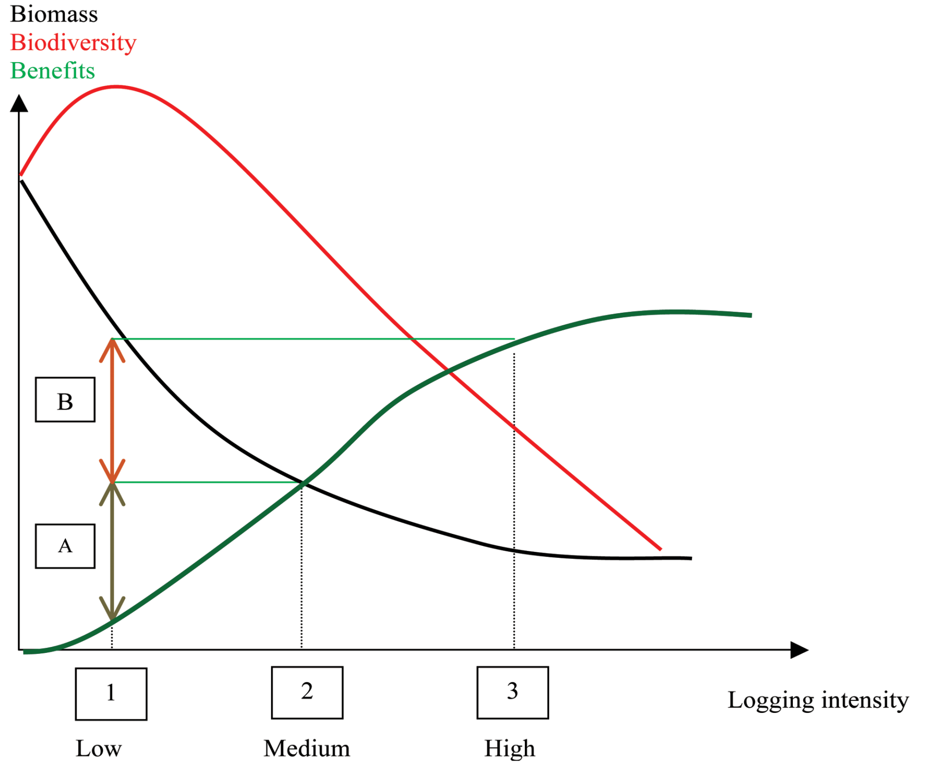

Figure IV 2.4 Theoretical trend curves for biodiversity, aboveground biomass (agb) and immediate logging benefits depending on logging intensity at a given moment. These curves can be used to define production compromises. In a context of payments for environmental services, A, B and A+B represent the lost earnings between the different compromises (respectively between 1 and 2, between 2 and 3 and between 1 and 3) and can form the calculation basis for assessing the cost of payments for environmental services.
Compromise 1: Low intensity and low financial earnings, high agb and biodiversity
Compromise 2: Medium intensity, moderate financial earnings, moderate biodiversity and agb
Compromise 3: High intensity and financial earnings, very low biodiversity and low agb.

dramatically in the near future because of our increasing human footprint and the effects of climate change and species migrations. It is therefore crucial to consider these novel forests in planning forest management practices.

To summarise, tropical silviculture needs to adapt to the new context of SFM, a context characterised by different types of forests, a diversity of forest stakeholders, and new demands for forest goods and services. Multiple management objectives need to be met within the same forestry production unit. The emergence of new payments for environmental services markets opens up economic development possibilities for forest-provided environmental services. Forest management practices cannot be implemented solely to sustain timber yield, rather they need to seek compromise between the production of forest products and environmental services (Figure IV 2.4). The main challenge that tropical silviculture faces is to identify the thresholds of extraction intensity compatible with the maintenance of the main environmental services targeted for a given forest management unit (Sist et al. 2011).

2.3 Forest management for different stakeholders and different objectives

2.3.1 Growing recognition of community and smallholder forest tenure rights

Tropical forest management was long dominated by logging companies that managed large concessions. However, it is estimated that approximately 800 million people in rural areas worldwide obtain important contributions to their incomes through extraction of timber and other forest products (ITTO 2011). For at least the past 20 years, rural populations have actively claimed their rights to benefit from the forest resources and to be recognised by legislation as legal and significant actors in the forestry sector. As a consequence, they indeed become more and more important although forest legislation still poorly reflects this new situation. The multiple local forest stakeholders have their own needs, capacities, perceptions, and forest-related livelihood strategies. They focus not only on timber production but also on using the forest for subsistence needs, commercially exploiting multiple forest products such as fuelwood, food, and medicinal plants, or pursuing ecotourism that also promotes their own cultural heritage. Several studies have demonstrated that community forest management, when it is formally recognised and land ownership is legally recognised, can effectively contribute to the conservation of natural forests (see Guariguata et al. 2012).

What is the importance of forest land owned or legally administrated by forest communities, whether they are ethnically mixed communities, indigenous people, or smallholders? A recent assessment of ITTO (2011) regarding the change of forest land tenure in 39 tropical countries between 2002 and 2008 shows a trend of recognition of forest communities' and smallholders' rights to forestland and forest use, particularly in Latin America. The survey shows that in the 30 countries with complete data, the absolute area of public forestland has decreased substantially, by 15% from 2002 to 2008 (1.3 million ha versus 1.1 million ha), while the forest areas designated for use by ethnically mixed communities and indigenous groups has increased by 66% (43 million ha versus 71 million ha) and 22%, respectively, during the same period (Figure IV 2.5). Finally, the forest area owned by individuals or private companies also increased by 122% (100 million ha versus 222 million ha). In 2008, governments in these 30 countries administrated 65% of the total forest area, while the private sector (ethnically mixed communities, indigenous people, smallholders and companies) administrated or owned 35% of the forest area. Ethnically mixed communities and indigenous groups controlled 22% of all forestlands (Figure IV 2.5).

Latin America showed the highest change in forest land tenure: forestlands administrated by government decreased by 45%, from 453 million ha in 2002 to 225 million ha in 2008. In comparison, Asian and African countries have shown almost no change in forest land tenure (Figure IV 2.6). The majority of African countries assessed in the report have only a very small percentage of forestlands administrated or owned by communities. The global transition of administration and ownership of forestlands from government to communities is happening in only a few countries, mainly in Latin America and particularly in Brazil. Brazil especially has pursued significant change in forest tenure towards the recognition of ownership of ethnically mixed forest communities, indigenous people, and smallholders, thereby demanding the use of different models, linked to diverse sets of rules, for forestland allocation and forest resource management (Pacheco et al. 2011).

From 2003 to 2006, Brazil created 487 000 km^2 of conservation units, in most of which traditional forest use is regulated and allowed. Smallholders who settled the Brazilian Amazon during the past decades are held responsible by the forest code for conserving at least 50% of their lands in forest. These forest reserves, which represent 12 million ha, can be managed following a forest management plan approved by the local authorities. According to the Brazilian Forest Service, forestland under the responsibility of communities and smallholders covers an area of about 40 million ha, which represents an area similar to that which can be given out as forest concessions (Amaral et al. 2007, SFB 2010). In the Amazon states with high levels of colonisation, where forestlands have been converted into pasture or agricultural lands or degraded by predatory logging, the contribution of communities and smallholders to forest conservation plays a major role since they still own forests in good condition with high timber volumes. In the state of Pará, for instance, it is estimated that communities and smallholders will in the future contribute to about 60% of the supply of wood to operating sawmills (Sablayrolles et al. 2013).

2.3.2 Community forest management and improved business models

The involvement of different actors in the management of natural tropical forest is undoubtedly one of the key issues in promoting large-scale SFM and preserving forests from degradation and conversion in the future. The so-called community-based forest management (CBFM) must therefore be developed to contribute more actively to the forestry sector than in the past, when logging companies were the main supplier of timber.

CBFM still faces many limitations in its implementation, execution, and financial profitability. Such limitations are partially caused by poor organisational capacity, lack of knowledge of forestry techniques, limited access to markets, and lack of regulations taking into account the specificity of CBFM. To overcome these difficulties, implementation of new communal forest management systems has usually been supported by public or international financial assistance. Unfortunately, most of these difficulties, particularly those related to forest regulations that are still poorly adapted to CBFM, usually persist once the financial and technical support has stopped and are a source of failure (Humphries et al. 2012, Drigo et al. 2013, Sablayrolles et al. 2013, Part II chapter 3).

To understand its limitations and to find solutions for promoting CBFM, it is essential to recognise the diversity of both actors and forest production systems. For example, a forest community managing a

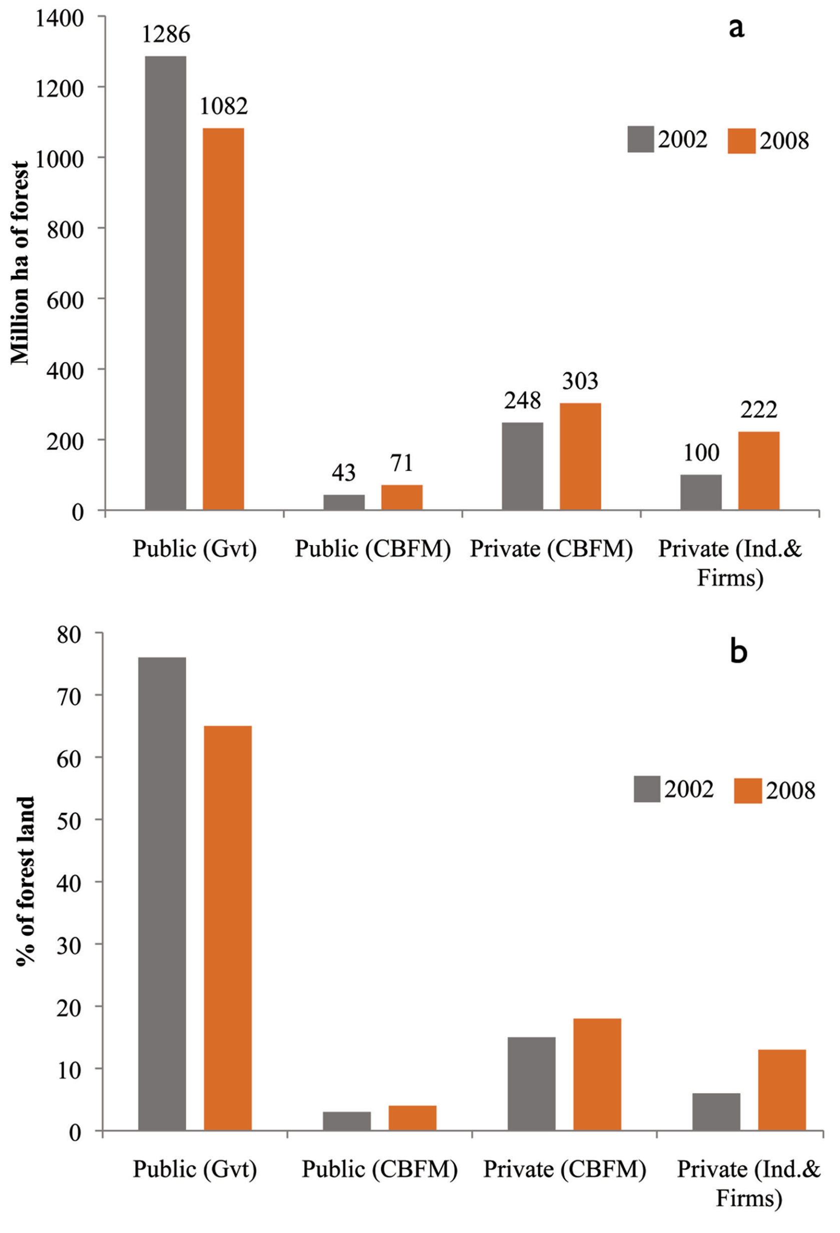

Figure IV 2.5 Forest tenure distribution by tenure category in 30 tropical countries with complete data for 2002 and 2008 (a: in millions of ha, b: in percentage of total forest cover).
Public (gvt): Public forest lands owned and administrated by government and not designated for use by communities or indigenous peoples.
Public (CBFM): Public forest lands designated for use by communities and indigenous (Community Based Forest Management).
Private (CBFM): Private lands owned by communities or indigenous groups.
Private (Ind. & Firms): Private lands owned by individual (e.g. farmers) or firms (e.g. logging company).
Source: ITTO 2011

common forestland of several thousand hectares will be more similar to a logging company managing a concession than to smallholders who individually own small patches of forests. In the first case, forest management activities may generate most of the community income but will require larger organisational and financial capacity, e.g. to implement silvicultural treatments. In the second case, forest management activities will provide only a part of the individual family income. This proportion of income seems to play an important role: long-term simulation of the income using different agrarian smallholder models suggests that livelihood strategies that include forest management for timber increase household resilience to adequately address risks and calamities (see Part II chapter 4).

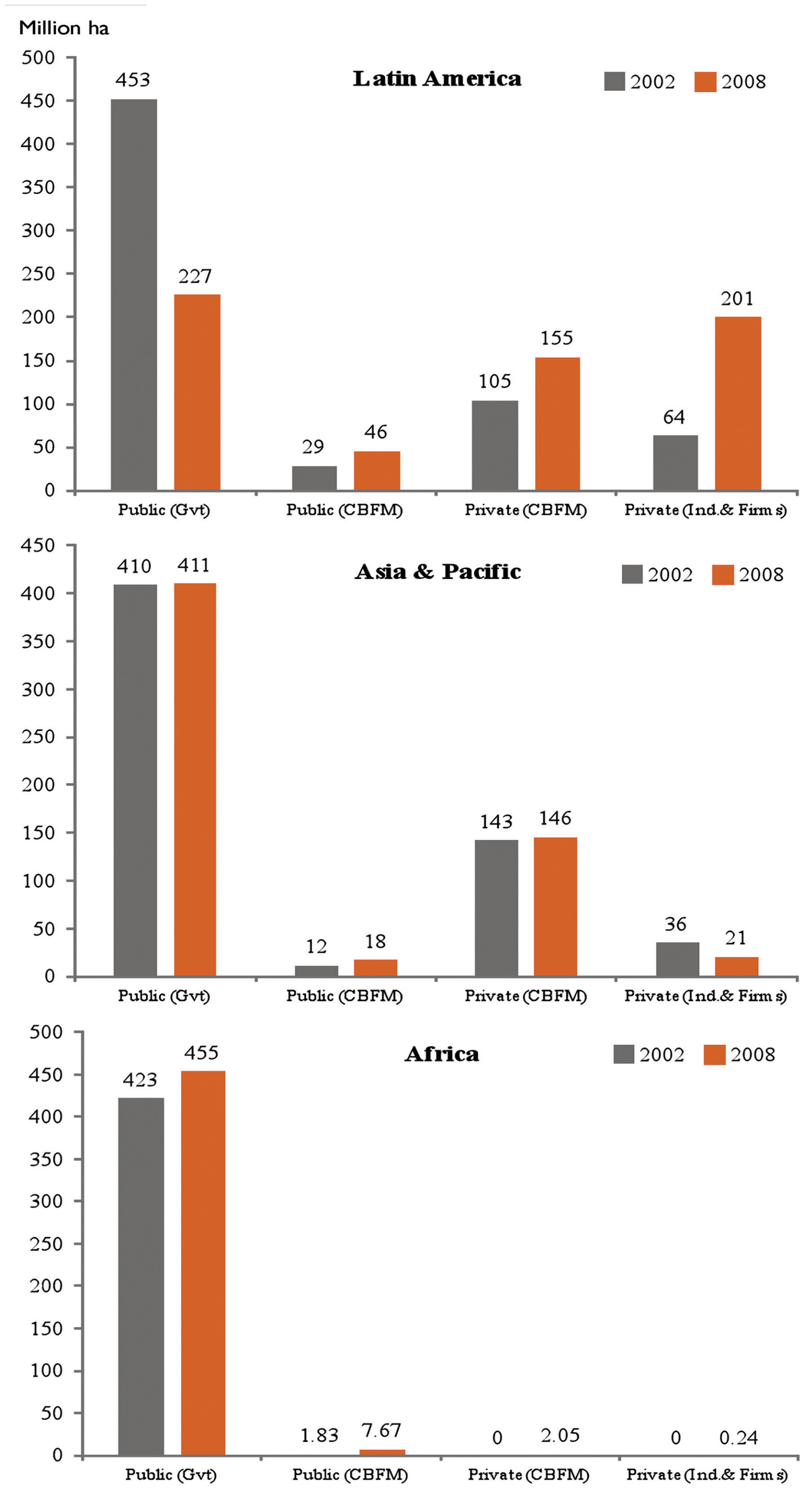

Figure IV 2.6 Forest tenure distribution by tenure category in Latin America, Asia and Africa including 30 tropical countries with complete data for 2002 and 2008 (in millions of ha). Source: ITTO 2011
Latin America: 8 countries accounting for 82 % of Latin American tropical forests (Brazil, Bolivia, Colombia, Ecuador, Guyana, Honduras, Suriname, Venezuela)
Asia: 8 countries accounting for 90 % of the Asian tropical forests (Australia, Cambodia, China, India, Indonesia, Myanmar, PNG, Thailand)
Africa: 14 countries accounting for 84 % of African tropical forests (Angola, Cameroon, CAR, Chad, Congo, Côte d'Ivoire, DRC, Gabon, Niger, Nigeria, Sudan, Tanzania, Togo, Zambia)

2.4 New forest policy and governance approaches

2.4.1 Current policy frameworks for forest management

In most forest-rich tropical countries, forest policies have focused almost exclusively on regulating timber extraction on public lands that were given out under concessions to logging companies (Karsenty et al. 2008). Forest management plans are seen as the primary instrument to regulate large-scale logging and to promote sustainable timber harvesting, associated with different stumpage-fee arrangements, often linked to the volume harvested on those public lands. These regulations, however, have in most cases failed to promote SFM, not only because the regulations were based on a narrow understanding of sustainability but also because of the constrained broader institutional context associated with forest management (Nasi et al. 2011).

Broadly speaking, current forestry legislation has two weaknesses. The first is that by favouring mechanised selective logging practised by forest companies, it does not adequately take into account the communities and smallholders that are undertaking multiple-use forest management. When legislation does consider communities and smallholders, it imposes large-scale industrial management models for a diversity of situations where local actors follow different rationales for making use of their forests (Pokorny et al. 2008). The second weakness is that forestry legislation tends, almost universally, to favour command-and-control schemes linked to verification of the legal supply of timber. The command-and-control approach is not only costly but relatively ineffective, resulting in substantial illegal harvesting of tropical timber often tied to bad forest management practices (Lawson and MacFaul 2010). In addition, this approach often penalises the local actors who cannot comply with the forest management regulations favouring large-scale industrial logging and perpetuates an extended informal sector. These cases are documented for Latin America (Pacheco et al. 2008), Cameroon (Cerutti et al. 2013), and Indonesia (McCarthy 2002).

By neglecting practices and aspirations of smallholders and communities, the policy frameworks fail to address the critical limitations that these local actors face, such as limited investment capacity, poor knowledge of silvicultural and harvesting techniques, and limited market information (Pacheco 2012). For example, the Brazilian Forest Code authorises logging in the forest reserve of agrarian properties held by smallholders only after approval of a management plan by the competent local authorities. The approval criteria, however, are more suited to large-scale mechanised logging operations by specialised companies than to farm forestry characterised by small areas, low timber volumes, low investment capacity, and inadequate knowledge of logging and business management techniques. Smallholders are thus forced to sell their standing trees, usually for a low price, to logging companies, many of which are illegal. These practices are detrimental not only to the smallholders, who make little money from their forest reserve and bear the legal responsibility for this illegal trade, but also to the regenerative capacity of the logged forest.

In other cases, smallholders and communities apply forest management practices that do not harm the forests in the long run, yet these practices are not recognised by forestry agencies or trained professionals. This often results in local actors using their forests rather informally (Pokorny et al. 2008). Furthermore, relatively high bureaucratic barriers and transactions costs impede compliance by smallholders and communities with forestry norms (Pacheco et al. 2008). A strong need exists to revise present legislation in order to take into consideration the specific conditions of community and smallholder forest management. Site-specific intervention models need to take into account the variety of contexts and community interests, rather than replicating models that have been successful elsewhere (Hajjar et al. 2013). Forest regulations will have to be flexible enough to be adapted to a broad diversity of forestry situations. Command-and-control schemes are likely to have limited effect in controlling illegal timber when the institutional conditions and incentive systems are not in place for the different local stakeholders to undertake long-term forest management.

2.4.2 Towards more integrated policy approaches

In most cases, forestry policy frameworks are devised in isolation from other sectoral policies, mainly agriculture and land policies and finance and trade policies. The lack of policy harmonisation is one of the main factors working against the maintenance of production forests and protected areas. Indeed, in many countries, unsecure land tenure constitutes an important bottleneck that inhibits investments and impedes long-term perspectives for natural resource management (Robinson et al. 2013). Important contradictions between forest policy and agricultural policy only increase with growing concerns for ensuring supply of food and energy, which also accentuates the existing conflicts between agriculture and conservation land use (Phalan et al. 2011).

The overall trend is for tropical countries to still

Box IV 2.1 The integration of forest and agriculture in the Brazilian Amazon

For more than 40 years, small settlers in the Amazon have been pursuing the same strategy: they clear the forest to grow food crops, like maize, rice, or manioc. After two or three years, the soil loses its fertility and requires an extensive fallow period. The settlers then convert their plots into pastures, since cattle ranching is the most profitable activity in the short term, and open new forestlands to grow food crops. If each of the 460 000 smallholder families in Brazil cleared just one hectare of forest per year, this would amount to 4600 km², exceeding the 3900 km² of annual deforestation that the Brazilian government set as the maximum for 2020. It is therefore vital that smallholders make their systems more productive and manage soil fertility more effectively. This requires the creation of mixed forestry-farming-ranching models that enhance natural forests while protecting them and that increase agricultural productivity. Considering the 12 million ha of permanent forest reserve held by smallholders in the agrarian settlements, the implementation of integrated forestry and agriculture practices will play a key role in reducing future deforestation. One way to develop such farm forestry is to regulate partnerships between smallholders and forestry companies. Defining rules and specifications guaranteeing the equity of contracts and the environmental sustainability of operations would create a favourable environment both for the development of farm forestry and for greater legal accountability of logging companies. In practice, companies undertake timber harvesting, although the smallholders remain legally responsible for the implementation and execution of the forest management plan. The control of the forest inventory, however, is of strategic importance, for instance in setting the conditions for the sale of timber. It is important to enable smallholders to control this crucial phase of forest inventory through financial support from the government or forestry credits.

give precedence to the expansion of agricultural land for commodity crops and of pastureland (Gibbs et al. 2010). In cases such as Indonesia, the rapid expansion of oil palm seems unlikely to decline due to a growing market demand and relatively weak state land-use regulations (Wheeler et al. 2013). In contrast, there is an emerging trend in the decoupling of expansion of agricultural crops and deforestation in the Brazilian Amazon because the expansion of soybean production is taking place in already deforested lands (Macedoa et al. 2012). This suggests that it is possible to increase agricultural yields without affecting forests. However particular institutional arrangements must be in place in order to integrate the apparently contradictory goals of agricultural expansion and forest conservation (Hecht 2012). In Brazil, there are explicit attempts to integrate forests and agriculture (see Box IV 2.1). While reducing the pressure on forests is a condition for SFM, clarifying forest use rights and incentives, which are often absent, are also required. The situation in sub-Saharan Africa (SSA) can be seen as the "last frontier." This is a place where a relative abundance of land, combined with relatively low population and weak government, appears to be open for grabs (Gibbs et al. 2010). It is very likely that we are going to see an expansion of both industrial (because of external demand) and family farming in many SSA countries in the coming decade. It is also likely that this will happen at the expense of forested lands.

Incentive systems to promote sustainable forest management require the adoption of a wider perspective of sustainable land management, not merely a focus on forest management. While recognition of the need for more harmonised policy frameworks for supporting socio-economic development is not new, stronger measures are needed for more articulated and holistic inter-sectoral approaches that support social welfare and complementing integrated natural resources management. Two interconnected goals are embraced by these emerging approaches. The first is the recognition of the importance of sustaining the provision of forests goods and ecosystem services under the notion of multifunctional landscapes (Fisher et al. 2009). The second stresses the need to optimise land uses to ensure adequate food and energy supply for a growing population without increasing the pressures on forests from expansion of cropland (Smith 2013). These two objectives go beyond the goal of SFM, yet SFM remains a fundamental element of multifunctional landscape management. This, in turn, makes the objective of sustainable forestry both more challenging and more complex to implement in practice.

2.4.3 Multi-level and multi-actor forest governance

The achievement of SFM in the tropics may only be possible under new governance architectures that embrace multiple interconnected levels from the local to the global and that engage multiple actors, including both state and non-state actors. The obstacles to good governance in the forestry sector are corruption, weak law enforcement, unclear tenure rights for land and trees, and marginalisation of local actors in the context of relatively costly and bureaucratic command-and-control approaches for ensuring legal timber supply. It is increasingly clear that multi-level governance of forest resources involves complex interactions of state, private, and civil society actors at various levels and of institutions that link higher levels of social and political organisation (Mwangi and Wardell 2012). Thus, forests governance increasingly embraces a whole range of institutional arrangements negotiated at different levels, connected in diverse ways (Agrawal et al. 2008, McDermott et al. 2010). These arrangements include negotiations by local stakeholders on ways to use forests and share their benefits, policy frameworks issued at the national level regulating how forest resources should be accessed and managed, and decisions from consumer countries on timber-market regulations (e.g. FLEGT[(2)], Lacey Act) or multi-stakeholder processes involving the private sector and civil society, such as in forestry certification (e.g. Forest Stewardship Council). Finally some global processes, such as the United Nations Forum on Forest, Convention on Biological Diversity, and United Nations Framework Convention on Climate Change, have diverse but not obvious impacts on decision-making about forests and in shaping SFM. The recently adopted Warsaw framework for REDD+[(3)] is an example of such global processes that if properly implemented, should reduce deforestation and degradation through a combination of incentive measures and rigorous monitoring and verification (http://www.forestcarbonasia.org/other-publications/warsaw-framework-redd-plus/). The combination of global governance and domestic policy leads to different pathways through which they can influence forest management (Bernstein and Cashore 2012).

Each of the governance mechanisms and processes mentioned, such as FLEGT, certification, and REDD+, have their own strengths and weaknesses in supporting forest governance, and thus SFM. For example, forestry certification is likely one of the most advanced schemes (Auld et al. 2008), but it has faced a slower uptake in tropical natural managed forests due to its high cost and failure to yield a premium price for certified timber. Yet, forest certification has the potential to improve weak normative frameworks that allow the unsustainable use of forests (Cerutti et al. 2011). While FLEGT conveys a sense of responsibility from consumer countries to halt timber associated with illegal logging, it may also tend to exclude smallholders who cannot comply with forestry regulations, despite the fact that their operations, in many cases, have lower effects on forest conditions than industrial logging (Atyi et al. 2013). What really matters, however, are the interactions of the different instruments and the combined effects from the supply side and the consumption side.

2.5 Discussion and conclusion

Tropical forest management must adapt to the new tendencies observed during the past decades. The first important change is the type of forest that will be managed in the future. For many tropical countries of Southeast Asia, for example, forests being logged have already entered the second cycle of timber production, but operators still act as if the forests were in their original state. Indeed, new regulations for timber extraction decrease the minimum diameter cutting limit in order to harvest smaller trees already present during the first harvest, while sustainability would require harvesting only trees that grew during the rotation duration to a harvestable size. As a result, the timber volumes being extracted today at second rotation are still very high and result in high damage while reducing the regenerative and elastic capacity of the forests. Future tropical silviculture will have to consider many different types of forests that were usually discarded in the past, such as secondary forests, degraded forests, agroforests, and novel forests (Nasi and Frost 2009).

It is therefore essential to assess the regeneration capacities of the existing logged-over forests on a regional scale, in terms of wood volume, non-timber forest products, biodiversity, and carbon stocks, and to make silvicultural recommendations that are adapted to the different types of forests in a given region. For example, in the very heart of the Amazon basin, there are major differences in structure, composition, and species richness that are important to take into account, as they will partly determine the regenerative capacities of forests after logging. The same is true for the forests in the Congo basin. Unlike the tropical silviculture of today, which still addresses primary forests with a large stock of timber, tomorrow's silviculture will deal with disturbed, sometimes degraded forests that will have to be strictly managed and in some extreme cases restored through intensive restorative silviculture. It will no longer be possible to settle for intervening during logging operations; it will also be necessary to turn to post-logging silvicultural treatments, such

(2) Forest Law Enforcement, Governance and Trade (FLEGT)
(3) Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+)

as liana removal around future crop trees, refinement and timber-stand improvement, and enrichment planting with species of commercial value.

Tropical silviculture must be an effective tool for forest conservation while ensuring benefits for a wide range of actors who manage from a few to thousands of hectares. Although, it is undeniable that various demands on tropical forests to provide multiple goods and services have increased during the past two decades, tropical forest management systems have made little or no progress in moving from timber-dominated models into more diversified ones aimed at producing multiple goods and services (Panayatou and Ashton 1992, García-Fernández et al. 2008, Guariguata et al. 2012). This in spite of widely acknowledged social and financial advantages of multiple-use forest management (Kant 2004, Wang and Wilson 2007). Multiple-use forest management could represent an alternative for generating complementary revenue between two timber rotation cycles, which often exceeds 30 years. In addition to non-timber forest products, services provided by tropical forest such as biodiversity, soil protection, and climate-change mitigation are now considered as potential sources of income under the mechanisms of payment for ecosystem services, for instance REDD+.

CBFM is usually considered to be less damaging than industrial logging. However, in many tropical countries, the so-called small-scale forestry implemented by rural populations is in constant evolution – in many cases, communities and smallholders implement mechanised industrial logging through partnerships with logging companies or even by themselves (see Part II chapter 3, Humphries et al. 2012). So the difference between CBFM and industrial logging is less and less obvious, but some CBFM characteristics such as small forest areas and use of only a few species still must be taken into account.

The generalisation of sustainable tropical forest management practices will not happen without important changes in forest resource governance and in how the pressures from competing land uses are managed. Three aspects are important with regard to the transition required in forests governance. First, policy approaches will have to adopt more plural and flexible views when considering the disparate perspectives of diverse actors related to well-managed forests. Second, forest policies are increasingly becoming part of more integrated policy frameworks to ensure the provision of forests goods and services in multifunctional landscapes rather than considering production forests in isolation. Finally, multi-scale governance approaches will be needed given the increasing interaction likely in the future between decisions made at the sub-national level with those taken by national governments as well as the influence that import market or investment regulations in consumer countries and certification processes may have in shaping decision-making around forest resource management.

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