TROPICAL FOREST MANAGEMENT TECHNIQUES

A REVIEW OF THE SUSTAINABILITY OF FOREST MANAGEMENT PRACTICES IN TROPICAL COUNTRIES

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TROPICAL FOREST MANAGEMENT TECHNIQUES: A REVIEW OF THE SUSTAINABILITY OF FOREST MANAGEMENT PRACTICES IN TROPICAL COUNTRIES

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FOREWORD

The principle of sustained yield is a concept that has developed over many decades of forest management and research. Most foresters are familiar with this concept and many attempts have been made to devise systems of forest management that follow sustained yield principles. More recently however, a broader concept of sustainable forest management has been introduced into the national and international policy debate about how forests should be managed. In contrast to sustained yield, sustainable forest management considers the sustainability of production of a wider range of forest outputs, rather than concentrating on one or two products (usually timber and, occasionally, non-wood forest products). There is currently still little agreement as to what exactly constitutes sustainable forest management, or how it should be achieved, although most commentators would probably agree that only a small proportion of the world's forest estate is currently managed in a way that is broadly sustainable.

It is against this background, that this paper has been commissioned by FAO on behalf of the World Bank to review and summarise current experiences with attempts to manage forests sustainably. Due to the difficulty noted above, it concentrates largely on attempts to manage forests for sustainable wood production, although it does also review what little information is available about forest management to meet other objectives. The paper only focuses on forests in tropical countries. Another paper in this series discusses progress towards sustainable forest management in temperate and boreal countries.

The paper is in eight main sections. The first two sections describe the extent of the tropical forest resource and discuss some of the issues that are currently being raised in the debate about sustainable forest management. The third section describes experiences from tropical countries around the world with sustained yield management and section four discusses forest management for objectives other than wood production. Sections five and six appraise experiences to date and discuss the scope for improving forest management in the future. Section seven makes recommendations about how forest management might be improved and the main findings of the report are summarised in section eight. A large number of very useful case-studies are presented in annexes to another version of this report, which is available in French as a separate paper.

This paper has been prepared by staff of CIRAD-Foret, drawing from the broad range of experiences of that organisation and a review of published materials. FAO would like to express its gratitude to all the contributors to this paper and to thank everyone that has provided comments on earlier drafts of this work. FAO will continue to explore, with member countries, the ways in which sustainable forest management can be implemented with greater success and to assist with implementation through its technical and normative work programmes. In this respect, we would welcome comments on all aspects of this study from readers.

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FOREWORD: THE TECHNICAL APPROACH TO THIS REVIEW

There are several difficulties when trying to interpret sustainability in a technical or scientific sense. These largely relate to the backgrounds and views of the various parties involved in the current debate about sustainability. The major difficulties are highlighted below.

- The first difficulty relates to the various objectives implicitly included in different definitions of sustainability. A clear statement of value-systems and objectives is necessary before any technical questions about sustainability can be answered. Only then can sustainability be properly translated into technical terms and used to develop a strategy to achieve such objectives.

- The second difficulty stems from the analytical approach typically used to address problems of sustainability. Sustainable development is a global issue that needs to be addressed at a global level and by using knowledge and techniques from a number of disciplines. The challenge for sustainable forest management is to design and implement management systems that are both practical and multi-disciplinary in their approach to resolving forest management problems.

- The third problem concerns the variety of different temporal and spatial scales over which sustainability can be measured. For example, global ecological changes such as the "greenhouse effect" occur at the largest scale but need to be addressed in operational terms at international, national, regional and local levels.

- The fourth problem concerns the inherently long-time periods that have to be considered in forest management. Trees have lifespans varying from several to several hundred years. Consequently, successive cycles of management may cover several decades or a thousand years. In view of the time it takes for forests to respond to changes in management, it is necessary to both think and act with a view to the long-term. This perspective contrasts markedly with financial and economic techniques used in forest management that tend to focus on the short-term. It also suggests that a precautionary approach should be taken when considering the management of tropical forests.

In a very practical sense, sustainability also involves some major methodological and measurement problems, particularly in terms of assessing different silvicultural practices. It is no longer sufficient to only assess the impacts of forest management on the forest. It is also now necessary to consider the impacts of management in the long-term on other economic, social and environmental systems (e.g. agricultural productivity, climate, and hydrology).

This report only addresses technical questions about sustainable forest management and does not consider moral or socio-political issues (it would be more appropriate for specialists working in these areas to investigate such issues). In other words, the report covers the technical debate surrounding the sustainability of various forest management methods and systems, rather than the wider debate about the goals of management.

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1 INTRODUCTION

Tropical forests cover about 1,680 million ha: 920 million ha in tropical South and Central America, 490 million ha in Africa, and 270 million ha in tropical parts of Asia and the Pacific. Dense evergreen forests account for 720 million ha, dense semi-deciduous forests cover 590 million ha and dryland forests cover 240 million ha (see Table 1). Current deforestation rates are estimated to vary from 0.7%/year in tropical South and Central America and Africa to 1.1%/year in tropical parts of Asia and the Pacific. Degraded forest areas cover more than 2 million ha.

Table 1: The current estimated global area of natural tropical forests

Type of forest	Asia and the Pacific	Africa	South America and the Caribbean	Total
Humid tropical forest	219	338	870	1,427 (85%)
Dryland tropical forest	41	151	46	238 (14%)
Mangroves	7	3	6	16 (1%)
Total natural tropical forest	267 (16%)	492 (29%)	922 (55%)	1,681 (100%) (100%)

Note: all figures are in millions of hectares. Sources: FAO (1993, 1994 and 1995).

Sustainable forest management is an objective of forestry policy in most countries irrespectively of the degree of human intervention in forests, consequently any discussion of sustainable forest management should include natural forests, secondary forests and forest plantations.

1.1 Humid tropical forests

This type of forest is used in many different ways. Uses range from fairly low intensity harvesting regimes (for example local hunter-gathering communities) to more intensive harvesting of non-wood forest products and game and commercial logging of varying intensities. Shifting cultivation is a type of forest use that can cause forest degradation, particularly if it practised using unsustainable techniques. Numerous similarities exist between regions and continents, although there are also some marked differences. In Africa, commercial forest operations have opened up roads and trails into the heart of vast previously untouched areas of forest, which are then penetrated by slash and burn farmers where population pressure is high. In South America, livestock ranching is considered to be one of the important drivers of deforestation. In Southeast Asia, overharvesting of stands containing large volumes of commercial timber is an important and often sufficient cause of forest degradation.

1.2 Dryland forests

Deforestation and degradation of dryland forests are caused by several man-made, climatic and biological factors. Drought conditions, combined with tree felling (mainly for conversion of forestland to agricultural uses), overharvesting of fuelwood and grazing, are the main causes of soil degradation and eventually lead to desertification. An estimated 70% of dryland forest areas in the tropics are affected by desertification, which leads to increased impoverishment of tree populations. This process is further accelerated by deliberate and accidental brush fires.

1.4 Plantations

The establishment of forest plantations can meet a number of needs, including: carbon fixing; the provision of a wood supply source that is an alternative to the natural forest; the restoration of degraded land; and the generation of income and employment. About 28 million ha of forest plantations in tropical areas can be considered as forest plantations for wood production. These plantations are mainly located in the humid tropical zone. A number of agricultural tree crops can also be considered as commercial plantations (including: rubber; coconut; and oil palm plantations). It is also currently estimated that more than 500 million ha of degraded land could be planted (or replanted) with trees. However, current rates of forest plantation establishment are only about 1.7 million ha/year (see Table 2).

Table 2: Industrial forest plantation area in 1995

	Area of forest plantations for industrial wood production (in million ha)	Annual increase in total forest plantation area (in million ha)	Proportion of total forest plantation area used for industrial wood production
Africa	2.43	0.12	52 %
South America and the Caribbean	5.97	0.23	76 %
Asia and the Pacific	19.11	1.30	45 %
TOTAL	27.51	1.65	

FAO (1997).

1.5 Secondary forests

Secondary forests are defined as woody formations occupying land where human intervention has destroyed the original natural vegetation (usually natural forest). At the end of the 1990's, there were 65 million ha of secondary forest in tropical South and Central America, 90 million ha in Africa and 87 million ha in tropical parts of Asia. This resource, although very important in many countries as a source of wood fibre, represents one of the most serious challenges for forest managers and policy-makers. This is because so little is known about how to effectively manage these areas, particularly in tropical regions. For example, forest cover can be restored naturally with adequate levels of forest protection. However, such a process would probably take hundreds of years before the forest regained its original structure and functions.

2 FOREST SUSTAINABILITY

In any discussion of the question of "sustainability", it is necessary to consider a number of temporal, economic, ecological and socio-cultural factors.

2.1 Timescale

Most ecological systems, such as forests, are in a permanent state of flux caused by naturally evolving biological processes and changes. Sustainable forest management systems attempt to develop systems whereby the renewable resource (e.g. wood or non-wood forest products) can be extracted without harming the environment and future generations (this implicitly assumes that such resources are permanent and renewable). A problem that arises when considering such systems is the question of the time-scale that should be used when analysing the sustainability of any particular forest management system. A lack of attention to this issue has caused numerous misunderstandings and the failure of many forestry development projects. A further complication is that perceptions about the appropriate time scale to use for analysis vary between different parties and individuals and can depend upon whether the analysis is considering sustainability in a biological, physical, financial or economic sense. If it is not possible to agree upon the appropriate time scale to use in any analysis of sustainability, it is advisable to take a precautionary approach to this issue.

2.2 Economic considerations

The diversity of tropical forests is reflected in the diversity of economic activities that are carried out within them. As forest resources become scarcer, there is greater competition for access to forest goods and services and conflicts of interest become more commonplace. Forests also often suffer from a perception that they are of less value than alternative land uses, although this is often associated with the problem of unclear property rights. Consequently, access to forest goods and services needs to be regulated in time and space. Forest conservation or sustainable forest management needs to be economically justified at different levels of society and amongst different groups. As part of this process, it is also important to note that forest areas cannot be managed independently from agricultural areas because both types of areas compete to meet similar basic needs and should therefore be considered together within the overall context of sustainable development.

2.3 Socio-cultural aspects of forest management

Sustainable forest management will only succeed if all stakeholders are fully aware of their own impact on forests and forestry issues and are held accountable for their actions. Policies and measures that are based on consultation and developed from the bottom-up should generally be preferred to those that are developed from the top-down. This requires that people should be educated, informed and made aware about the impacts of their activities so that they can incorporate sustainable forest management objectives into their decision-making. For this to happen, it is important that the role and rights of each stakeholder are acknowledged and understood. The establishment of an open and constructive dialogue is a necessary condition that must be met in order to find appropriate solutions to the complex problems involved in sustainable forest management. This requires that all stakeholders in forest management (including both forestry company personnel and local people) operate in healthy and satisfactory conditions.

2.4 Ecological considerations

Tropical forests cover only 7% of the world's total land area, but contain more than 50% of all living species. Thus, they contain some of the most biologically diverse areas on the planet and are rich in species (some of which may not yet have even been discovered). The long-term value of forest genetic resources cannot currently be quantified because, despite the exhaustive efforts of forest taxonomists, the value and variety of species that they contain, along with the needs of future generations, is still not known or understood. Emphasis on biological diversity usually leads to the formulation of forestry policies for natural forests that concentrate on objectives of conservation or preservation, whereas sustainable forest management recognises the economic necessities of sustainable production of goods and services (see, for example, Table 3, which shows how tropical forests are currently classified according to the primary objective of management). Where environmental and economic needs conflict, conservation and development are not always incompatible and can usually be reconciled through some form of sustainable forest management.

Table 3: Area of tropical forest categorised by main management objective in 1990

Management objective	Asia and the Pacific	Africa	South America and the Caribbean	Total
Production	151	58	100	309
Protection	44	8	90	142
Conservation	27	18	26	71
TOTAL	222	84	216	522

Note: areas are in million ha. Source: FAO (1995).

3 THE STATE OF TROPICAL FOREST MANAGEMENT: MANAGEMENT FOR SUSTAINABLE WOOD PRODUCTION

3.1 Current global status of forest management

Great efforts have been made in recent years to draft and implement forest management plans. Nevertheless, in only a few cases have management plans been implemented effectively and fully. In 1990, undisturbed natural tropical forests represented only about 155 million ha, or about 30% of world's tropical forest areas used for wood production. The other 70% are constantly being harvested and are thus in more urgent need of being managed in a sustainable manner.

3.1.1 Use of forest resources for industrial timber production

Globally, there are approximately 330 million ha of logged-over tropical forests. In the tropics, more than 148 million m^3/year of industrial roundwood is extracted from a potential sustainable production of 134 million m^3/year. However, only 18% of total roundwood production is for industrial purposes (see Table 4), 18% of which ends up on international markets. FAO (1997) has estimated that, at a global level, there is a tendency to overharvest timber resources. The ratio of sustained yield production (potential production versus volume actually harvested) provides regional trends of the degree of forest harvesting regimes (see Table 5). It emerges that:

- the situation in Africa varies by region: in Central Africa, extraction volumes exceed production while in West Africa, the threshold of sustainable forest harvesting has been largely surpassed (and production is now more than 200% of sustainable yield in some cases);

- in South America, in general, the levels of sustainable yield and current harvesting are in equilibrium, but most forests in Central America are overharvested (with harvesting up to 10 times the sustainable yield in some cases);

- in Asia and Oceania, forests are generally overharvested, with harvests largely exceeding (by at least 70% and often more) sustainable yield, not taking into account forest clearing and illegal felling.

Table 4: Global consumption of forest products in 1994

	Product				
	Fuelwood and charcoal	Industrial roundwood	Sawnwood	Wood based panels	Total
Consumption (in million m^3)	1,697 (76%)	406 (18%)	112 (5%)	30 (1%)	2,245 (100%)

FAO (1994)

Table 5: Production forest areas in 1990 and current levels of roundwood production compared with sustainable yield

	Undisturbed forests (in million ha)	Disturbed forests (in million ha)	Average production 1990-95 (in million m^3)	Production as a percentage of sustainable yield
Africa	59.6	112.9	17.1	174%
Asia and the Pacific	53.0	91.9	97.6	59%
South America and the Caribbean	42.1	122.5	33.8	141%
TOTAL	154.7	327.3	148.5	91%

Source: FAO (1997)

Table 6: Biomass and rates of degradation for natural tropical forests

ECOREGION	Potential biomass (tonnes/ha)	Current estimated biomass harvest (tonnes/ha)	Ratio of degradation (biomass harvest/ potential biomass)
CONTINENTAL ASIA			
Low-lying humid zones	449	225	0.50
Low-lying dryland zones	244	76	0.31
Mountain zones	306	155	0.51
PENINSULAR ASIA			
Low-lying humid zones	543	273	0.50
Mountain zones	504	254	0.50
TROPICAL AFRICA			
Low-lying humid zones	412	299	0.73
Low-lying dryland zones	92	60	0.65
Mountain zones	197	105	0.53

Source: FAO (1997)

3.1.2 Use of forest resources for fuelwood production

Fuelwood consumption accounts for almost 75% of global wood production. However, most of this biomass appears to be harvested outside established forests (in shrublike formations, perennial crops, hedgerows and gardens etc.). In highly populated and deforested areas, especially in Asia, forests still supply around 25% of fuelwood requirements even though many forests are overharvested. Other observations about fuelwood use include the following:

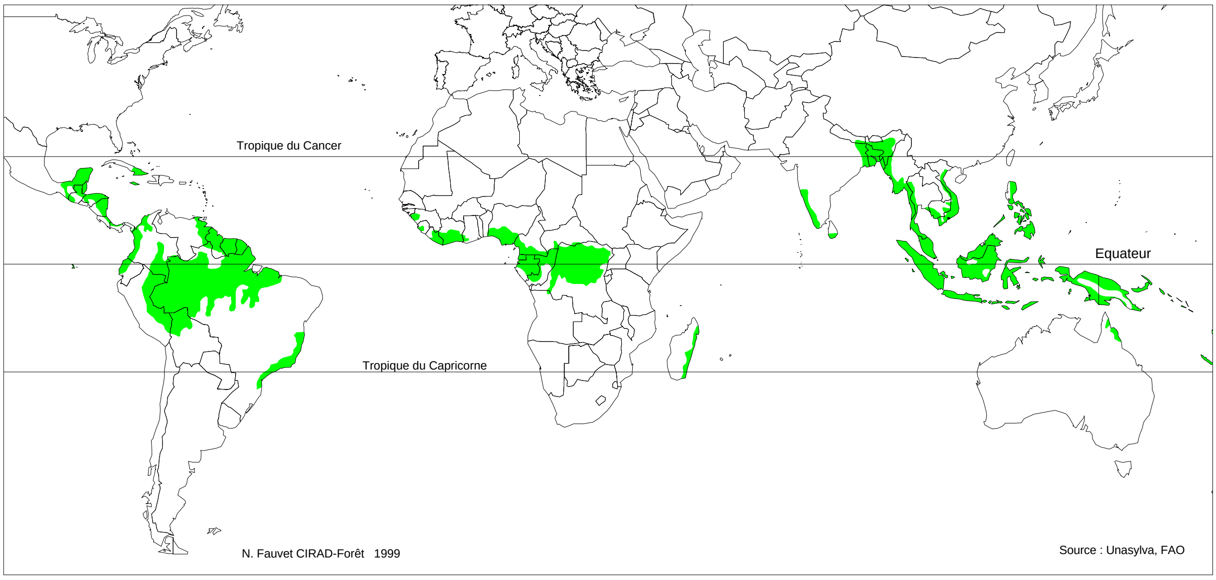
- the overharvesting of forests increases with the scale of people's needs as is the case in: India and Bangladesh; mountain forests in Burundi and Rwanda; dryland forests in West Africa (Niger, Nigeria, Togo and Benin); and in Southern Africa (Botswana, Somalia, Zimbabwe, Malawi), but current biomass removals represent less than 50% of sustainable biomass production (see Table 6);

- in the world's humid zones, the situation is more favourable in Africa than in Asia and worrying levels of biomass harvesting occur in: Indonesia; peninsular Asia; the Philippines; and Sri Lanka.

3.2 Humid tropical forests

The location of the world's humid tropical forests is shown in Figure 1.

Figure 1: The location of humid tropical forests



3.2.1 The characteristics of humid tropical forests

Africa. Despite the floristic variety and the abundance of large trees in African humid tropical forests, these forests (covering approximately 340 million ha) contain only a relatively small number of species that can be considered commercially viable. Harvesting is often far below the potential volume that can be removed, in part due to strict market requirements that make concessionaires concentrate on harvesting only the currently highly valued species (the "redwoods") that are mainly located in remote inland areas. Harvesting intensity in these forests is typically between 10 m^3/ha and 40 m^3/ha.

Asia. In general, humid tropical forests in Asia (covering approximately 220 million ha) are characterised as having an abundance of trees of similar size, with fewer large trees per hectare than are found in African forests. However, tree diameters are generally greater than those found in tropical South and Central America. The dominant family - the dipterocarps - contains most of the high value species. The good technical timber qualities of these species and their abundance on the Asian islands are reflected in large-scale commercial harvesting activities there. Harvesting intensity is generally high at about 70 m^3/ha and often more.

America. Humid tropical forests in tropical South and Central America (covering approximately 750 million ha) contain less species diversity and trees tend to be smaller than in other regions. The main species generally lack the good technical timber qualities that have been the source of commercial forestry success in Asia and Africa. As a result, harvesting intensity in the humid tropical forests in tropical South and Central America is generally lower, with rates of between 5 m^3/ha and 30 m^3/ha.

3.2.2 Assessment of past forest management practices

Historically, Asia has had the most potential for industrial wood processing development on the basis of existing wood processing technologies and the markets for tropical wood. Consequently, numerous humid tropical forest areas in this region have become impoverished where formerly dense forests occupied vast areas. Now, some former net wood products exporters have become net importers (e.g. Thailand and the Philippines). Faced with this impoverishment of the forest resource, many countries in the region have become aware of the need to implement sustainable forest management systems.

Compared to the situation in Asia, attempts to implement sustainable forest management are a more recent phenomenon in Africa and tropical South and Central America. However, there has not, to date, been any integrated implementation of management planning systems in these regions. In fact, the need to properly manage forest resources has only been recognised and enforced in the last few years, following recent international awareness of the threats to forest resources from ranching and agricultural activities.

For a long time, sustainable forest management projects really only examined silvicultural techniques aimed at managing forests for sustainable wood production. Systems examined included:

- the "Malaysian Uniform System" (MUS) in Southeast Asia;

- the improvement of natural stands system or "L'Amélioration des Peuplements Naturels" (APN) in Africa; and

- the "Celos Management System" (CELOS system), tested in Surinam.

A range of silvicultural treatments were developed, tested and implemented in research into these various systems, that emphasised sustainable wood production. However, many of these experiments have failed, in that they have been only partly implemented or have not been maintained over a long enough time period to produce really reliable results.

The technical feasibility of these systems has rarely been a cause of failure in these experiments. For example, despite the fact that Malaysian and Indonesian sustainable forest management systems were only partially implemented (because of a number of problems), the evidence from the Asian experience suggests that it is very likely that tropical forest management for sustainable wood production is technically possible. Similar research programmes were started in South America, but have been interrupted because of socio-economic and political problems there (e.g. controversies over land rights). Application of sustainable forest management systems in Africa has been limited by the limited resources available to forest administrations in most African countries.

Furthermore, political changes have often had the effect of changing the orientation of forestry institutions in many countries, encouraging them to give preference to techniques that promise to produce faster results (e.g. development of forest plantations) rather than develop sustainable supplies of wood from the slower growing natural forest.

In general, the main obstacles to a better understanding of tropical forest management arise from a lack of knowledge about the application and results of various silvicultural treatments and a poor understanding of ecosystem dynamics, particularly techniques for promoting adequate forest regeneration after harvesting. Improved knowledge about these subjects would be useful to strengthen the basis on which sustainable forest management systems are developed. However, it is generally believed that the results obtained to date (from numerous studies and projects) have provided a reasonably solid basis for effective silviculture in humid tropical forests. Difficulties encountered with implementing sustainable forest management have more often been found outside the technical arena, in areas such as: land development policy; socio-economic conditions; and political circumstances.

3.2.3 Constraints and difficulties encountered

Technical and scientific issues. Good inventory data is a prerequisite for any sustainable forest management project. However, more often than not, inventory data are unreliable, obsolete and/or inaccessible, due to a lack of resources and/or investment in this area. Information about productivity or growth of valued species and their long-term yield is also scarce. In fact, databases (numerical, cartographic and bibliographic) that group together all available knowledge about climate, soil, topography, flora and fauna, are often lacking at the regional, local and national levels. Improving the flow and storage of management information is an economical and efficient way of continuously improving management and databases containing this information should be created and continuously updated using a permanent flow of field observations.

The choice of forest management techniques in any particular forest area is determined by two factors: management objectives and inherent stand characteristics (e.g. yield potential, fire risk, etc.). A technically sound approach to silviculture can be articulated in terms of three requirements:

- harvesting at a rate that is compatible with wood production potential or yield;
- making sure that harvesting and extraction is planned in a correct and timely fashion; and
- encouraging the growth of highly valued species while maintaining biodiversity.

Management according to these principles (e.g. by assessing growth, harvesting in line with these estimates and choosing the most appropriate harvesting practices) is difficult and, in reality, forest administrations in most countries do not have enough staff to approve and monitor management plans. In other words, adequate knowledge about sustainable forest management techniques is available in most cases, but implementation is poor due to limited resources.

Socio-economic and political issues. During the implementation of any long-term forest management plan, the political and socio-economic context is likely to change. If management plans are not flexible enough to respond to such changes, they can be called into question and finally abandoned therefore, possible future changes in context and circumstance should be taken into account.

Neither stability nor long-term forecasts can be guaranteed in many developing countries because there are numerous factors that can generate unpredictable conditions that are incompatible with sustainable forest management (e.g. pressures to expand agricultural production, infrastructure developments and economic crises such as the recent crisis in Asia). Against this background, negotiation and periodic adaptation of management plans should be guided by the long-term objectives of management. Furthermore, political discussions about overall objectives are often neglected, leading to high-level administrators questioning the plan at the last minute if they are not consulted earlier. Greater attention should be given to the social and institutional framework within which forest management plans are produced and implemented.

In general, local communities are often very dependent on forests. It is therefore, important to promote their participation and to maintain a dialogue with them during the formulation and implementation of forest management plans. Divergent objectives among the various stakeholders can often lead to conflicts of interest, so it is also essential to emphasis the long-term benefits to each of them and describe how they will be affected by the management plan. The major problem here is to extend the "temporal and spatial horizon" of stakeholders so that natural forest resources are not overharvested to meet short-term requirements.

3.3 Mangroves

3.3.1 Mangrove characteristics

Mangroves cover more than 16 million ha and include a limited number of haliophilic species (e.g. Rhizophora, Avicennia, etc.). These forests are exposed to strong ecological limitations due to cyclical tidal flooding and, consequently, mangroves represent one of the most vulnerable ecosystems on earth. Nevertheless, mangroves can be very productivity and they play important protection and economic roles (e.g. by stabilising coastlines and supporting local fisheries). They supply extremely varied goods and services and numerous communities depend on them for their survival.

3.3.2 State of forest management

Mangroves appear to be well preserved in countries with low population density and adequate wood resources (e.g. Gabon, Guyana and Australia). In contrast, they are in decline in areas with high population pressure (e.g. Senegal, Thailand, Vietnam and Bangladesh). For example, in the Philippines and Ecuador, mangroves have been illegally converted to use for intensive aquaculture operations while, in Indonesia, they have been overharvested for other purposes (e.g. timber production). In East Africa, the main reason for decline in mangroves has been conversion into salt marshes.

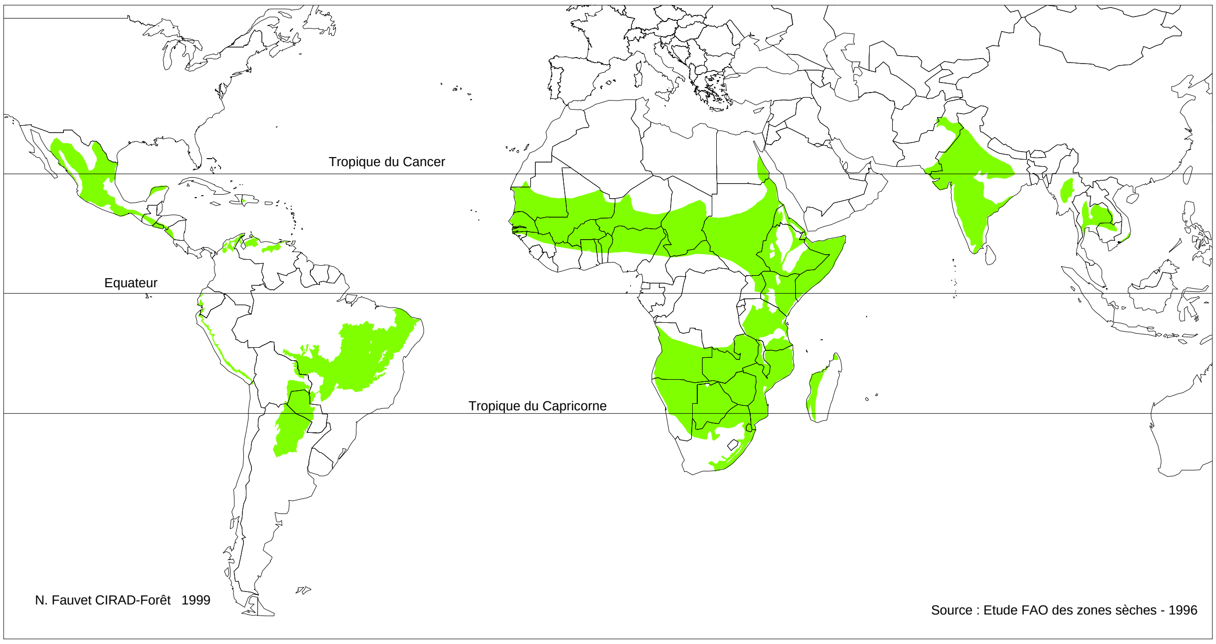
It is rare is for mangroves to be sustainably managed for wood production (including wood fuel and industrial roundwood production) except in some Asian countries such as: India; Bangladesh; Thailand; and Malaysia. Australia seems to have the best management systems in place for mangroves, including areas for protection and conservation of these resources (e.g. they have 23 protected national parks and sites) and other areas for sustainable harvesting.

Mangroves play a recognised role in protection against coastal erosion and the conservation of aquatic fauna. This importance has been recognised in much of Asia and Central America, where reforestation and the restoration of degraded mangroves has been carried out with these objectives in mind. Technically, mangroves can be managed for sustained yield of wood and non-wood forest products. However, management depends considerably on other factors, especially variations in the water regime and therefore, the management of inland coastal areas should be integrated into mangrove management systems.

3.4 Dryland forests

The location of the world's dryland forests is shown in Figure 2.

Figure 2: The location of dryland forests



3.4.1 Dryland forest characteristics

Dryland tropical forests are composed of a mosaic of different ecosystems, including dense dryland forest, open forest and woodland formations, single trees, and scrublike savannahs. There are 238 million ha of dryland forests in the world and Africa alone has 64% of that amount. These ecosystems provide shelter to nearly 1 billion people and half of the world's domestic livestock, not to mention a large variety of wildlife.

3.4.2 Reasons for resource degradation

For almost 50 years, these dryland regions have been weakened through repeated drought and human intervention (e.g. the erroneous use of fire as a management tool, conversion to agricultural land, overgrazing and overharvesting of forest resources, etc.). Wood from these ecosystems accounts for between 50% to 90% of energy used in Africa (but far less in Asia and tropical South and Central America). For a long-time (and still today), fuelwood has been considered as a free resource, with the only price being the cost (usually in terms of time) of harvesting it. Open access to resources (land, forest and rangeland) and the absence of land security have contributed to the destruction of this resource. Unrestricted forest clearance and fuelwood collection has far exceeded the ecosystem's capacity to regenerate naturally. Furthermore, the expansion of cultivated land has reduced the land available for traditional livestock breeding, leading to greater use of the forest for seasonal migration, where the forage produced by certain woody species complements grazing.

Table 7: Proportion of total energy needs met by the use of wood fuel in several tropical countries

	Year		
Country	1978	1982	1990
Senegal	60%	82%	54%
Mauritania	69%	94%	na
Mali	93%	90%	80%
Burkina Faso	94%	94%	91%
Niger	88%	95%	80%
Chad	89%	na	80%
Côte d'Ivoire	65%	60%	72%
Thailand	na	na	24%
Philippines	na	na	43%

Note: na = not available. Source: FAO (1992)

3.4.3 State of forest management

In dry tropical zones, forest harvesting generally exceeds the sustainable level of supply. Furthermore, dryland forests are rarely managed properly despite the presence of various management planning systems in all three continents. In Asia, several forest management trials have been established in dryland forests, but without any apparent success to date. Very little is known about current systems for dryland forest management in tropical South and Central America. Dryland forest management is considered important in Africa and Madagascar and this is reflected by the substantial number of projects carried out or ongoing in this region. However, at present, most of these projects are mainly pilot projects aimed at analysing participatory approaches to forest management.

Up until 1970, "classical" forest management systems were mainly applied to dryland forests in most regions. However, the forest management plans based on these systems were never really applied effectively, because of a lack of popular participation and insufficient knowledge of an environment that was much more complex and vulnerable than in many of the other countries where these systems had originally been developed.

In the 1980s, numerous projects were initiated in Africa, usually with one main management objective (e.g. industrial timber or fuelwood production, or wildlife management), but again with limited popular participation. In a few cases, local people were consulted and/or formed into forest management groups or local conservation committees. Eventually awareness of the particular problems of dryland forest management (e.g. inherent difficulties of managing dryland areas and the complexities of dealing with many stakeholders seeking many different benefits) led to the reorientation of the objectives of projects towards more decentralised management of natural resources, with particular attention being paid to the benefits sought by local people.

Considerable effort was also made to halt or even reverse desertification, which is the final stage of dryland forest degradation, by implementing programmes such as: afforestation with exotic species; planting "green barriers"; agroforestry development; and other measures. Unfortunately however, despite significant investment in these projects, this problem is far from being resolved and results have fallen far short of expectations. In the case of forest plantations, this was due to excessively high costs of most schemes and rejection of such schemes by the general public in many cases. Many other regreening activities failed because they were not effectively linked to the implementation of other policies (e.g. agricultural and pastoral policies).

A final point to note with respect to dryland forests is that wildlife should be a vital component of forest management plans because they are an important source of meat and other non-wood forest products that are consumed by local people. In addition to this, wildlife resources are also important for the tourism economy in countries such as: Kenya; Tanzania; and Zimbabwe.

3.4.4 Constraints and difficulties

Technical and scientific issues. Still not enough is known about the complex biological interactions that exist in dryland forests and the way that they evolve and function. For example most experiments and inventories in dryland forest ecosystems have focused only on wood production, rather than on management for multiple objectives. Sustainable forest management in these areas needs to be integrated with other land uses (i.e. integrated agro-silvo-pastoral management), which makes it necessary to be familiar not only with the forest, pastoral and agricultural resources, but also the with wildlife and various non-wood forest product resources (e.g. honey, gum, etc.) present in the forest. Agro-silvo-pastoral management systems should also encompass management of natural forests, multiple-use tree plantations, windbreaks, shelterbelts and hedgerows.

Faced with growing demand for agricultural and pastoral land, it is important to apply techniques aimed at improving and maintaining the productivity of agricultural land and rangeland in conjunction with forestry programmes, in order to avoid land degradation. Soil erosion and a drop in soil fertility effectively restrict all sustainable management options. Water management is another critical issue in these regions that, by definition, only receive small amounts of rainfall each year with which to grow plants and replenish groundwater supplies. Brush fires also limit sustainable management. They can be managed through the deliberate burning of high-risk areas at the beginning of the dry season, together with appropriate grazing pressure.

Socio-economic and political issues. The main constraints to dryland forest management stem from legal and socio-economic factors. These include: complex relationships between stakeholders and the forest; contradictions between land law and customary law (e.g. with respect to ownership of forest resources and user rights); and difficulties in replacing current agricultural and livestock production methods with new forms of rural land organisation and natural resource use. Nevertheless, given the prevalence of poverty in these regions, the improvement of food security is an absolute prerequisite to sustainable development. In effect, the main constraint to the implementation of sustainable forest management plans is the intensity of land use. Even in heavily degraded areas people still depend, to a great extent, on what remains of the forest to meet their basic needs. In order to eliminate an important source of pressure on dryland forests, it is vital to provide permanent solutions to the population's energy problems. As in other types of tropical forests, management plans in dryland forests have also been abandoned or poorly implemented due to inadequate monitoring by forest administrations and political pressures for change in the longer-term.

3.5 Degraded tropical forests

3.5.1 Characteristics of degraded tropical forests

In degraded tropical forests, past unsustainable land management practices have led to the replacement, partially or totally, of forest ecosystems by grasses, shrubs and other invasive species. Such degradation can be caused by overharvesting, shortening of shifting agricultural cycles, or excessively high cropping pressure leading to a drop in soil fertility and abandonment of the land. Degraded forests are characterised by a low soil fertility and poor soil structure, considerable soil erosion and high susceptibility to fire.

3.5.2 Suggested measures for improvement

Degraded tropical forests cover more than 2,000 million ha in total. Depending on the degree of forest degradation, several management actions to restore fertility and/or to promote site productivity, can be undertaken:

- **Secondary forest management.** Secondary forests emerge naturally on land where human intervention has destroyed the original vegetation. They have reduced species diversity but, in terms of silviculture, are relatively easy to treat. However, their intrinsic value is also lower than in primary forest, except in some instances such as with *Aucoumea klaineana* and *Cordia alliodora*. Global interest in secondary forests has recently increased since it has been estimated that they cover more than 350 million ha (50% of which is in tropical South and Central America), but knowledge about this type of forest and its development is very limited.

- **Conversion to forest or agricultural tree plantations.** Conversion of secondary forest to forest plantations or agricultural tree plantations (e.g. rubber trees, fruit trees and palm trees) is an acceptable option to meet protection and production objectives in a technical sense. Furthermore, such plantations generate income, employment and can even help the global environment by storing carbon.

3.6 Assessment of forest management - other types of forest

3.6.1 Forest plantations

Most large-scale tropical forest plantation establishment (e.g. teak in Asia) has taken place during the last half of this century. The rate of tropical forest plantation establishment world-wide has progressively increased, particularly in South America and Asia (mainly in Brazil and Indonesia, respectively). Experience has shown that the most important factors to consider when establishing a forest plantation are the objectives of management and the vulnerability, in ecological terms, of the site to be planted.

To date, most forest plantations have been established as even-aged monocultures, mainly using exotic rapidly growing species (e.g. eucalypti, acacias and pines). These species appear to be technically easier to manage and control and more profitable (for wood production) in the short-term. The result of this trend has been the restoration of productivity in some forest areas at the cost of a drop in biodiversity and heightened vulnerability to disease, pests and fire. In contrast to single-species plantations, mixed forests have fewer pest control problems, fire is inhibited due to their multi-layered composition, they can restore and maintain soil fertility and they present a more varied range of development possibilities.

Experience shows that wood yield from forest plantations appears sustainable if species are adapted to the site and if effective management methods are used. In fact, most failures in forest plantation projects occur due to bad species selection or mismatching species and site or the absence of forest maintenance and follow-up activities. In such cases, failed forest plantations can actually accelerate soil erosion, water pollution and siltation of watercourses.

Tropical forest plantation establishment and management techniques are currently well known for many species. Measures to improve tropical forest plantations have yielded notable results, but socio-economic and technical constraints (e.g. low manpower availability and difficulties in expanding the result of experiments to large areas) have led to a greater interest in the development of intensive mechanised methods.

Given current forest product prices, forest plantations nearly always turn out to be too costly to be economically viable in the short term. Furthermore, when considering that the revenue from plantation investments arises in the long-term, they are constantly exposed to various risks, such as: collapses in prices; natural disasters; and political instability. Another factor that has to be taken into account in the appraisal of tropical forest plantation programmes, is their impact of on the landless and poor people who are directly competing to use the land. In some cases, tropical forest plantations have led to the eviction of traditional users, upset existing systems of harvesting and extraction for local use and fostered serious social conflict. Thus, it is necessary to consider the wider impacts of such developments, but little concrete information about such issues ids usually available.

3.6.2 Agroforestry

Agroforestry encompasses a large number of land use systems ranging from those where trees are planted on farming land to those where agriculture is practised on forest lands without leading to deforestation. In some regions, notably in Southeast Asia, multiple-use trees have been planted in agricultural areas in order to increase productivity and restore soil fertility.

The development of agroforestry systems has seen great progress over the last ten years thanks to new research the testing of new techniques and improvements in extension. However there is still room for progress in the development of sustainable management systems that are biologically and socio-economically robust.

3.6.3 Secondary forests

In view of the scale of forest resource degradation, secondary forest management has recently become an important aspect of tropical forest management and represents one of the most important challenges to managers in tropical regions today. Forest cover can be restored naturally through natural plant succession and forest protection. Nevertheless, the development of older trees is necessary before the forest regains its original structure and composition. This process is slow and experience shows that many degraded sites are exposed to periodic disturbances (e.g. fire) that can inhibit natural regeneration and halt recovery. Very often, short fallow tree cycles (of several decades) are used as a means of restoring degraded site fertility prior to reusing the land for agriculture. It is useful to consider this in combination with long-term forest production and conservation options, as an option for the management of secondary forests.

Secondary forests hold considerable production potential for wood and non-wood forest products and provide numerous environmental functions, including: climate modification; soil protection; biodiversity conservation; and amenity. Furthermore, sustainable management of secondary tropical forest can help to restore undegraded forestland.

Projects with objectives to manage secondary forests have generally failed in the past because of economic reasons (e.g. high costs) and conflicts over land uses. Long-term objectives to restore secondary forests should recognise that there will not be any immediate financial returns to such investments. This requires that the indirect benefits of forest cover regenerated in this way are taken into consideration in the decision-making process.

The main problem with sustainable management of secondary forests is that natural succession in such complex systems is not properly understood or known and considerable investment in research is required to provide some answers to important questions. However, from a technical point of view, the long-term results are likely to be unpredictable because of the many different outcomes that may arise from natural ecosystem evolution, which are difficult to model using current knowledge and techniques.

4 THE STATE OF TROPICAL FOREST MANAGEMENT: FOREST MANAGEMENT FOR CONSERVATION AND PROTECTION

4.1 Biodiversity conservation in forest ecosystems

Conservation of natural forest ecosystems is the main function of most protected forest areas and the term "protected area" encompasses a vast variety of approaches for the management of natural and semi-natural forest types. Protected forest areas currently cover only 5% of the tropical forest area and the rate of growth in protected forest areas has declined in recent years due to increased land use pressure. However, national parks and forest reserves are no longer the only method that can be used for the conservation of biological diversity. A possible alternative is multiple use forest management, which incorporates harvesting of forest products within a framework of sustainable management that aims at both conserving biodiversity and supplying benefits to local people and the national economy.

4.1.1 Protected areas

Although protected areas have been established that enjoy strict legal status, numerous problems arise in tropical zones in relation to their management. Problems include conflicts with local people over land rights and illegal extraction of animal and plant resources to mention just a few examples. These problems are often intensified due to the inability of state authorities to protect such areas. Hence, stated conservation achievements do not always reflect reality. In practice, even though there are good examples of effective national parks and forest reserves, the past hundred years or more have witnessed a parallel increase in both the number and surface area of protected areas and a growing number of extinct or threatened species. In effect:

- **The equation "protected areas = ecological diversity" is not necessarily true.** The location of conservation areas is problematic, because information is lacking about the presence of plant and animal species in different types of forest stand. Up to now, plans for the designation of protected areas have been based on three main criteria: biogeographical divisions between the main ecosystems in a country; the degree to which resources are threatened or degraded; and high rates of diversity or species endemism. The representativeness of protected area systems is seriously restricted both by a lack of information about the way species are distributed and pressures from other types of land development. Furthermore, protected areas do not always ensure that biodiversity will be protected because they often cover limited surface areas and are divided up randomly.

- **The equation "forest classification type = level of conservation" is not automatic.** Management practices in any particular area of forest are not always equivalent to the status that is supposedly given by its classification. For example, a complete natural reserve (i.e. a complete ban on human activity in the area) represents the maximum level of conservation that can be awarded, but this type of management can actually lead to less conservation than expected. To put this another way, the classification of a forest area does not guarantee protection if financial and human resources and political will do not support such a classification. In particular, in some countries, natural resource conservation is not considered a priority and short-term objectives are generally considered to be more important. Therefore, biodiversity needs to be understood more accurately from an economic and socio-cultural point of view. It should be given real value by integrating it into all economic decisions, in order to reconcile economic development and conservation interests.

4.1.2 Buffer zones: a solution?

Experience has shown that legal protection alone is not enough to ensure effective conservation activity. In particular, protected areas will only fulfil their conservation goals if the land around them is managed appropriately. In reality, many protected areas suffer from encroachment by farming and cropping activities. Currently therefore, the objective of biodiversity conservation in forests can only generally be ensured by the creation of substantial areas of natural forest for production around them. Such a "buffer zone" can support the protected area while, at the same time, provide local people with benefits.

Buffer zones are meant to form a physical barrier against human encroachment of the centrally protected area that also extends the natural habitat area of the protected area to beyond its legal boundary. Furthermore, the support of local people in conservation objectives can be promoted by their participation in the harvesting and management of buffer zones (e.g. through the use of appropriate agroforestry practices; hunting; establishing forest and agricultural tree plantations; and other activities). However, one drawback of buffer zones is that the economic development they generate can attract people to them and increase pressure on resources.

4.1.3 Production forests

Management of forests for multiple outputs is more compatible with the goal of biodiversity conservation than management for wood production, but forests managed for wood production can also have a role to play. The notion of "extractive reserves" is one approach to conservation in production forests that allows local people, who depend on the forest for their livelihood, to harvest products (e.g. timber, non-wood forest products, game, etc.) at a low intensity.

4.2 Sustainable wildlife management

Africa, which contains some of the most well known wildlife resources, is symbolic of the problems encountered in sustainable wildlife management. Wildlife habitats are being reduced and degraded by agriculture, livestock rearing and the overharvesting of forest resources. In addition, wildlife poaching is the source of extinction or near extinction of many wild animal species. Indeed, habitat degradation and excessive game hunting are the two main threats to fauna sustainability.

However, wildlife is also being used for tourism (e.g. hunting and ecotourism), mainly in Africa. Besides the financial value of these activities, this method of utilising wildlife resources should be ecologically and socially viable, but it is important to remember that wildlife also has considerable socio-cultural importance (e.g. religious and mystical significance).

In the past, authoritarian management of wildlife resources (i.e. the complete protection of wildlife) often failed. Measures taken to protect wildlife in such a way have harmed local communities and defied traditional cultural values. Total bans on the use and marketing of game have also forced communities to poaching.

Given the "*res nulius*" legal status of game, local people, when they are marginalised from wildlife management, consider wildlife as a free resource with open access. Although the state is generally the only body responsible for these resources, it is often unable to assume its management role. The implication of all this is that it is not generally possible to manage natural resources and fauna sustainably without the active participation of local communities in decision-making and subsequent benefits. Integrated community programmes for resource conservation have been formulated with success in several African countries, especially in the south (e.g. Botswana, Zimbabwe and Zambia), leading to a considerable drop in poaching, an increase in animal populations and to habitat regeneration.

Today the notion of biodiversity development and sustainable use is generally to be preferred to the idea of a total ban on the trading and marketing of wildlife and related products. As part of this, it is important to consider the potential multiple-uses that wildlife can provide, such as: recreation; food; and scientific, cultural, economic and ecological functions.

4.3 Fire protection

Although fire is a natural component of many forest ecosystems, it can damage vegetation and consequently lead to soil erosion and a loss of fertility if not used properly. Likewise, fires may also have harmful effects in that they can lead to carbon emissions during combustion. It has been proven that most forest fires are caused by human intervention due to a number of different causes, including: deliberate deforestation (i.e. forest conversion), slash and burn cultivation; rangeland regeneration (for grazing and hunting); accidents; traditional use (e.g. religious and tribal ceremonies); and political and socio-economic conflicts over land use and ownership rights (e.g. land use conflicts, conflicting land claims, arguments over debts, etc).

Fire is used as a tool to open up vast wooded areas for agriculture. Statistics indicate that more than 15 million ha of wooded areas are burnt each year for this purpose. However, if used properly and with care, fire is a valuable tool for farmers and herders. In forestry, for example, it is used in the preparation of sites for establishing plantations or to encourage natural regeneration. Nearly 500 million people practise shifting cultivation using fire over an area of 300 million ha to 500 million ha each year. Increases in the size of cleared areas and a shortening of crop rotation cycles is leading to increased resource degradation.

Even in humid zones, forest fires are occasionally the main cause of deforestation (e.g. in 1997), particularly in the Brazilian Amazon and in Indonesia. Drought, combined with the “El Niño” phenomenon, has resulted in forest fires of serious dimensions in several recent years. At the beginning of the 1980s, exceptional periods of drought, coupled with the Harmattan, led to the outbreak of numerous fires in Africa from Guinea to the Central African Republic. Forest fires can cause considerable tree mortality and forest destruction if repeated and then bare soils, that are subsequently covered in easily inflammable weeds (e.g. *Imperata* and *Chromolaena odorata*), are very difficult to regenerate naturally.

Forest fires in sub-humid and humid African areas can be the most important obstacles to the sustainable management and conservation of forest resources. More recently in 1998, in Central America, the Caribbean and in Brazil, many forest areas were damaged by fire.

From the 1970's onwards, trials of various mechanical means of controlling brush fires were carried out using modern apparatus (e.g. fire trucks, pumps, etc.). The high cost of these methods of fire control led to the promotion of greater participation of local communities, education and training, and the use of small equipment and manual tools in fighting forest fires. However, deliberate and controlled burning at the beginning of the dry season is by far the safest and most effective fire protection method in most cases.

In reality, problems of fire control are more sociological in nature than technical. Effective fire control is more a matter of popular education and agricultural policy than direct control and response.

4.4 Management for soil and water conservation

In tropical regions, most watersheds contain a large farming population. Particular agricultural arrangements, like terraced farming in Asia, present tried and tested soil and water conservation functions. On the other hand, reforestation in areas degraded by farming and grazing has turned out to be an expensive technical solution. In consultation with local people, improved forest protection will often lead to natural regeneration and enable secondary forest to be restored in many instances.

In natural forests that are managed for logging and which are located on steep slopes, the effects of these activities on watersheds will depend mainly on the layout of roads and skid trails and the quality of their maintenance. Other important factors are the felling and skidding techniques used, silvicultural treatments, protection against fire and pests, and other forestry activities.

Forested watersheds that provide water to densely populated areas should be protected against shifting cultivation and unplanned urbanisation. The only "management" in such cases should be effective surveillance to protect forest cover. Associating the functions of water supply and natural reserves for wildlife and plant life in the same watershed (examples of this occur in national parks in Kenya and Tanzania) does not generally present any technical problems and water management carried out downstream from these areas can be successful.

5 ASSESSMENT

5.1 Obstacles and pitfalls

Degradation of tropical forest resources is closely linked to illegal or excessive use, which is explained by a number of often-coincidental factors (or pitfalls), such as:

- **Climatic:** desertification, flooding, hurricanes, etc;

- **Demographic:** including a global rise in needs and thus growing pressure on natural resources (demography and standards of living are linked here);

- **Political:** including state or government insecurity, inability to ensure sustainable and monitored management and absence of international consensus in the form of a forest convention;

- **Economic:** including an erosion of living standards and the indirect impact on resource harvesting and a drop in government resources for the management of protected areas and managed forests;

- **Financial:** including little reinvestment to maintain forests as a source of multiple products or which, if it does occur, is often out of all proportion to the benefits and services provided;

- **Institutional and regulatory:** including unaccountability among village communities for natural resource management that are, in fact, considered free and for free access by local people and, in the case of some natural resources (mainly fuelwood, wildlife and non-wood products) that are the sole responsibility of the state, the inability of the state to assume its duties;

- **Circumstantial:** such as industrialists' preference to focus on "sure" commercial species that are well known on markets, such as Meliacea species (e.g. *Swietenia, Khaya, Cedrela* and *Entandrophragma*) in order to minimise commercial risks;

- **Conceptual:** such as the classical "conservationist" concept of nature conservation, which excludes man to the detriment of socio-cultural and economic needs and has not gained popular participation and can thus lead to unexpected results;

- **Psychological:** with distrust (sometimes deep-rooted) among various stakeholders (e.g. government, private companies, communities, ecologist movements, NGOs, researchers, donors, etc.), which prevents the development of positive and negotiated actions to settle conflicts over forest resources (there are numerous examples of such problems, including: the chimanes in Bolivia; the Deng-Deng in Cameroon and the current conflicts in Indonesia);

- **Ergonomic:** in other words, that tropical forests represent a hostile and difficult context to work in for many people and which these people consider leaving sooner or later due to family, professional or cultural constraints; and

- **Technical:** including the ignorance of the precise nature of resources and the best way to harvest them, alongside inconsistency and incapacity for resource maintenance and replenishment.

The time factor can also lead to many failures if it is not considered properly, including:

- **The replenishment of forest resources** that requires a lapse of time that is deemed excessive by many decision-makers, beneficiaries and even technicians;

- **The time lapse required for research** aimed at identifying the forest's evolutionary mechanisms often leads to failure due to experimental exhaustion and lack of sustained technical and financial support; and

- **Temporal perception** is variable and incoherent according to each stakeholder, their scale of values, the issues and approaches. For example, the impatience of decision-makers and donors can lead to short cuts, choices and approximations that speed-up results, but can consequently lead to results that are disappointing or misleading. The validity and technical sustainability of forest operations are also subject to changes in opinion. Opinions are exposed to changes in aims brought about by changes to international trade law and also by variability in short-term priorities, irrespectively of the knowledge gathered on current options that are sustainable.

The diversity of forest ecosystems is another source of diverging and conflicting interests and which heightens difficulties in study and approach owing to its inherent complexity. This is illustrated by:

- **The conflict between "conservationists and developers"**, which should not take place but nevertheless persists;

- **The dichotomy between forest fragility and their protection role.** Forests cover fragile and relatively infertile soils, which can become laterite if degraded rapidly. However, they also represent one of the most robust ways to protect and rehabilitate such soils;

- **Difficulties in applying silvicultural rules** to tree stands with similar specificity, nature, structure and evolution that are not identical to the original site where such rules were developed. This problem with silvicultural experiments is combined with the challenge of successfully applying techniques that have been tested in accessible, well known and well studied modestly sized forests, in other large forest areas;

- **Problems of appropriate resource assessment**, which require a lot of common sense in order to avoid expensive and/or badly designed inventories that lead to inappropriate harvesting regimes and recurrent problems, such as: inaccurate estimates of productivity; inadequate rotation periods; and poor management planning; and

- **The impossibility of precisely reconstructing** the nature, structure, composition and production functions of a primary forest used (even moderately) for timber production. For example, commercial Meliacea forests in tropical South and Central America (*Swietenia*, *Cedrela*), dryland and humid forests in Africa (*Khaya*, *Entandrophragma*, *Lovoa*), Dipterocarp forests in Asia (*Shorea, Parashorea*, *Dipterocarpus*, *Dryobalanops*, *Vatica*) and many other types of tree formations such as those with Burseracea

(*Aucoumea*, *Dacryodes*) have taken thousands of years to develop and can not be recreated after disturbance, even in the long-term.

5.2 Principles for overcoming the obstacles

Designing and implementing successful sustainable forest management means respecting basic rules. Many of these rules have been learnt from numerous forest management operations in the tropics over several decades. These rules allow for a shift in evolution from simple and rigid models towards complex ones that are closer to reality.

The simple models were	***The complex models are also***
centralised	decentralised
imposed	negotiated
top-down	bottom-up
for revenue	for resources
based on control	also stress training
a limited risk	a shared risk
for species	for biodiversity
for wood	for products

5.2.1 Towards participatory management and a multi-disciplinary approach

At present, the most common approaches to sustainable forest management are largely analytical and based on technical models of forest ecology. However, sustainability has to be considered globally by integrating knowledge from many different disciplines. The challenge is to create approaches to the formulation and implementation of sustainable forest management that are both operationally feasible and multi-disciplinary in nature.

Participatory forest management, for example, is a recent evolution towards such an approach. It works with a common set of methodologies that take into account the following stages in order to achieve improved forest management:

- managing rights and ownership patterns;
- reconciling scale constraints - from local to international;
- adapting management to suit the various stakeholders;
- using economic procedures that are valid for everyone;
- communicating, instructing and following through changes; and
- supporting participatory methods.

5.2.2 Towards diversified production

Past experience has shown that forest management for sustainable wood production can compromise the production of other forest goods and services. Now it is acknowledged that sustainable forest management means also taking care to maintain the productive, protective and ecological functions of forest ecosystems. Sometimes wood production enters into conflict with those other forest functions, especially when it conflicts with the activities of people living in the forest. However, non-wood forest products are often considered secondary products because their market potential and importance for subsistence are significantly underestimated. Non-wood forest product production is likely to be the main motive for local people to participate in sustainable forest management.

5.2.3 Towards a long-term vision

Trees are slow-growing perennial plants and the dynamics of tropical forest formations take place over time scales ranging from several decades to several centuries. The long time that tropical forests take respond to management activities means that forest managers and policy-makers must also think in the long term as well. However, this long-term approach conflicts with current financial and economic techniques that typically stress the short term and which are often very important tools used in forest management decision-making.

There will also be considerable methodological and measurement problems with thinking in the long term, especially in assessing the results of silvicultural practices. Furthermore, it is no longer simply a question of assessing the effects of silvicultural practices on the forest ecosystem, but also the long-term possible consequences of silvicultural practices on other systems (e.g. agronomy, climate, water, etc.).

5.2.4 An integrated approach: from national to local

Global ecological changes (e.g. the "greenhouse effect") should be viewed in a global context, but actions should take place at all levels. For success at the local level, there also has to be a favourable policy environment at international and national levels.

The international environment. The last 25 years has seen the emergence of an awareness of a number of sustainability and environmental issues (see Box 1).

The national environment. Land use planning takes place within a national framework and consequently so do choices regarding the determination of the permanent forest estate. Fairly accurate assessment of resources and their evolution over time are essential as part of this process. The supply potential of different products, whether they are industrial, food, pharmaceutical, artisanal, or other, should also be assessed as accurately as possible. This includes a need for research and information about the productivity of forests.

In addition to information about forests, information about capital and labour productivity should be collected, as should information about wood product supply and demand. Broader information about how the national environment might evolve and how industry and resources might respond to changes in markets is also important.

The presence of an overall land use policy is a necessary prerequisite to action on sustainable forest management. It must be emphasised that this is predominantly a political debate where technical specialists often have little input. The forest manager should develop technical activities within the context of the development strategies or options that have been chosen. The role of the state should be to supply a suitable environment in terms of policies, legislation and regulations and simple and flexible management methods should be designed so that local communities can easily employ them.

Box 1: The international environment

1972	*UN Conference on the environment. Stockholm.* *Creation of UNESCO and the Man and Biosphere Programme (MAB).*
1976	*Creation of the African Timber Organization (ATO).*
1983	*Creation of the International Tropical Timber Organization (ITTO - operational since 1987).*
1983	*Establishment of Tropical Forestry Action Plans (TFAP) by FAO and, later, National Forestry Action Plans (NFAP).*
1987	*Development of the concept of sustainable development.*
1992	*Rio Summit (Earth Summit): declarations on environment and sustainable development, forests; conventions on biodiversity, climate change and desertification. Establishment of the Commission on Sustainable Development (CSD)*
1997	*Intergovernmental Forum on Forests (IFF).* *Kyoto Summit: agreements to limit carbon dioxide emissions.*

The local environment. Some transfer of forest management responsibility to local communities is now a generally accepted means of action to support sustainable forest management. This generally involves two complementary approaches:

- **the patrimonial approach,** which is predominantly social and based on a heightened sense of responsibility and solidarity among generations that is strengthened by constant partnership; and

- **the village area approach,** which is predominantly eco-geographical, with activities centred on the development of infrastructure and human resources and the improved management of natural resources.

In management plans designed for local level, land, resources and equipment have to be managed in harmony with all stakeholders.

6 ASSESSING THE SUSTAINABILITY OF CURRENT FOREST MANAGEMENT PRACTICES

Assessing the sustainability of forest management requires having relevant criteria and indicators at both the local and global levels. In many instances, the lack of sufficiently detailed figures obliges forest managers to resort to precautionary principles in order to avoid irreversible resource degradation.

The design of criteria and indicators aimed at formulating structured definitions of sustainable forest management as well as consensus and assessment tools, is taken into account by many international bodies. Even if the complexity and diversity of circumstances restrict their field of geographical application, these criteria and indicators will play a positive role in improving sustainability as long as they lead to reliable standards for measurement and initiatives such as ecolabelling.

Even after ten years of effort to implement ecolabelling, it appears that this initiative will not meet global aspirations for improved forest management, particularly in Asia and even in Africa, due to a lack of demand and the small size of markets for such products in many countries in the Northern Hemisphere. Ecolabelling is also affected by other uncertainties, notably the legitimacy and independence of some organisations and institutions currently operating in this field.

For a number of reasons, it seems that systems of criteria and indicators and ecolabelling schemes will not meet their full potential without a conventional framework such as an international agreement or "forest convention", which contains some legally enforceable mechanisms.

7 TECHNICAL BASES OF MANAGEMENT PLANS

The main aim of any sustainable forest management plan should be to produce a plan for resource use that is acceptable to all affected stakeholders (including taking into account the interests of future generations) and avoids irreversible choices. In theory, the production of a forest management plan includes the following three key stages:

- **Analysis of the forest and its environment:** including: the legislative and regulatory context (e.g. land use planning and regulations); historical and human situation (e.g. social needs and cultural aspects); socio-economic assessment (e.g. economic needs, infrastructure requirements and market developments); assessment of the natural environment (e.g. fauna and flora in forest stands); and the technical options envisaged (e.g. family/community felling, intensity of harvesting and replanting activities).

- **Production of a clear statement of management priorities and activities:** including: a hierarchy of production objectives; suggested forest zonation; approved choice of technical options; statement of planned treatments (e.g. schedule of harvesting and silvicultural activities); and a social, economic and environmental justification for the decisions taken.

- **Establishment of a follow-up assessment and monitoring mechanism:** that will measure performance against each of the objectives set in the plan and allow the periodic revision or updating of the management plan if necessary.

The design of a forest management plan should integrate at least four types of information in its content: social, political and cultural factors; physical, biological and ecological factors; financial and economic factors; and technical elements (e.g. possibilities for silviculture, harvesting and processing). In order to ensure forest survival, forest management should also satisfy local people's requirements for land and forest products. Knowledge of the forest ecosystem, its evolution, potential and development options will be useless without an in-depth analysis of related agricultural, political and social factors.

It must always be borne in mind that tropical forests are complex and still relatively unknown ecosystems located in areas that are very diverse in terms of their socio-economic structures. Attempts to try and simplify the complex relationships within these ecosystems and between these ecosystems and surrounding human populations, have largely failed in the past. It is important therefore, to be realistic and adopt a flexible approach to forest management that is suitable at the many different levels of management (i.e. local, regional and national) and to realise that there is unlikely to be any universal methodology that can be applied in all cases.

7.1 Recommendations for sustainable forest management

To be sustainable, forest planning and management should aim for appropriate development of all natural resources (including: water; soil; plantlife and wildlife) while, at the same time, maintaining the health and vitality of forest ecosystems.

7.1.1 Planning forest management

With the right management, forests can produce a range of services and products (wood and non-wood forest products) in a way that is sustainable. Conservation and improvement of the protection functions of forests should also be encouraged in a forest management plan.

Periodic assessment of the status and condition of forest resources should be ensured in a permanent and continuous manner. This should take into account both biotic and abiotic factors that can have an impact on the vitality of forest ecosystems (e.g. parasites, overgrazing, fire, climate change and pollution). Management plans should consider all resources, users and ownership rights and should be periodically updated. They should define the resources and methods needed to minimise the risk of forest degradation and should seek to rehabilitate previously degraded ecosystems. They should be based on consultation and exchange of information among all the various stakeholders affected by the plan.

7.1.2 Forest management practices

Activities should aim for a quantitative and qualitative balance in growth and extraction by minimising direct and indirect damage to the resource. Regeneration, harvesting and maintenance activities should be programmed in space and time in order not to reduce the site's productive capacity. Infrastructure should be planned so that it minimises negative impacts on the environment. Silvicultural treatments should promote structural diversity in forest stands and encourage natural regeneration. Afforestation of fallow or deforested land should be considered a priority each time there is a possibility to increase economic, ecological, social and cultural values from such activities. Afforestation should rely on species and silvicultural methods that are appropriate for each site. Appropriate measures should be taken to balance the pressures of livestock herds and grazing on forest regeneration and growth, as well as on biodiversity.

7.1.3 Research

Tropical forest research has come in for criticism because it is (or has been perceived in the past as being) remote from reality. Nevertheless, many experimental activities have been pursued in the tropics, particularly in the very practical area of the evolution and dynamics of forest stands subject to human intervention (usually after harvesting). Yet much remains to be done. For example, the growth characteristics of high value species, such as Meliacea, *Swietenia macrophylla* and *Cedrela odorata* in tropical South and Central America, are still largely unknown. This makes it difficult to manage them sustainably, because of a lack of information about how to obtain sufficient regeneration.

A lack of staff trained to produce and implement sustainable forest management plans is also part of the problem. To find a way around this obstacle, field researchers are convinced that the best training for forest managers of the future can be obtained if they spend some time working in forest research.

7.1.4 Technical requirements

Certain forest management tools still need to be refined, including: field inventory techniques; tele-detection and geographical information systems; the use of sample plots to monitor forest stands; and activities that increase the quality and value of standing wood. Finally, it is important to have easily useable and updated forest resource databases to enable rational resource management decisions to be taken.

7.2 Humid tropical forests

7.2.1 Forest harvesting

Forest harvesting plans should be produced at least one year before field operations in order to avoid tractors rambling in search of trees to fell. Production of these should include inventory operations to single out trees to be harvested and planning of main and secondary road and skid trail networks. Compliance with the plan should form an essential part of monitoring by the forest authorities. Maintenance and drainage work on roads, respect for maximum slope gradients for skidding tracks and stocking and transport areas, should be obligatory. While difficult to enforce, another essential measure is to employ suitably sized cutting machinery (oversized machinery leads to many problems such as soil compaction). Strips of forest along riverbanks should be kept in good condition in order to maintain water quality and to provide habitats for plants and wildlife.

7.2.2 Natural regeneration

The vitality of natural regeneration affects the way that harvested stands renew themselves and harvesting disturbances can have a negative effect on the rest of the stand. In the first place, the stand is destabilised by the increased mortality of young trees. If more than one third of the stand is opened up, short-lived and invasive pioneer species may also become established to the detriment of species with structural, biological and/or commercial value. In some cases, after two to three years mortality may drop, but it generally remains higher than in untouched stands.

Recruitment of young trees and the growth of medium-sized trees (i.e. the next commercial crop) are stimulated over periods of, for example, ten years. It is suggested that the cutting cycle should generally be proportional to the extraction intensity (e.g. 20 years for a harvesting intensity of 5 m^3/ha to 15 m^3/ha, but 50 years or more for harvesting in excess of 25 m^3/ha.

7.2.3 Assisted regeneration in natural stands

Regeneration should preferably be promoted through the application of traditional silvicultural treatments. Short rotation (20 to 30 years) selection systems can only be applied within stands rich in species and under conditions where overabundant large-sized and/or less valuable trees are also removed as non-commercial thinnings. Otherwise, longer cutting cycles (e.g. about 50 years) should be employed. The lowest acceptable limit for harvesting diameter will depend on forest structure and composition (as well as other factors such as markets or processing possibilities) and no standard recommendation is valid. In all instances, not more than 30% of the total forest area should be affected by harvesting operations, in order to avoid irreversible stand destruction.

The systematic improvement of forest stands by non-commercial thinning of less valuable tree species can be justified within homogeneous and rich forests, but should be avoided in poorer stands where treatments cannot be economically justified because of their high costs. In the latter case, it may be best to envisage only selective clearing confined to the areas right next to the trees to be promoted. Treatments must be planned with the intention of helping to conserve biological diversity. Moreover, it should be emphasised that, in the framework of management, clearing work should preferably not be entrusted to a concessionaire but instead to a "practising professional" forest service.

7.2.4 Enrichment

This silvicultural treatment is usually applied to natural stands that are poor in commercial species. Enrichment planting entails complementing the stocking of currently commercial species by planting seedlings (usually 3-4 metres apart) of valuable species, adaptable to the site, in parallel rows (20-30-metre apart) in the forest. This method has been used all over the world (sometimes successfully) over relatively modest but well monitored areas. Enrichment has the merit of preserving the natural forest intact without disturbing it too much but there are also inconvenient aspects to this approach, including: the difficulty of controlling such activities; the long-term planning required for such treatments, and the high labour and other costs of continuously carrying-out such activities.

7.2.5 Conversion to plantations

This activity involves felling and replanting degraded forest stands of low productivity. Methods vary in intensity in line with the availability of resources and management objectives. The following aspects of such activities have to be taken into consideration: the suitability of the site and the reforestation technique that will be used; the utilisation of high-performance plant material; the maintenance of young plantations; the behaviour of artificial stands (e.g. the need for clearing and pruning); protection and plant health issues; and the technical quality of the wood that will be produced. In an attempt to reduce the destruction of standing and remaining vegetation, one version of this approach is to open two to three metre wide strips or transects in the forest in parallel rows several meters apart (depending on the species). As the planted seedlings grow in response to the need for more direct sunlight, the canopy is then opened progressively until the plantation exceeds the height of the remaining surrounding vegetation.

Cost considerations are important when choosing amongst all of the various plantation establishment options. For example, different methods can be used to convert degraded natural forests to plantations, such as: manual methods; mechanised methods; or a mix of reforestation and agricultural activities. However, the choice that is made has to consider ecological, economic, sociological and technical criteria. Manual methods usually imply having to utilise a considerably large labour force, which is not always available at the right moment. Therefore, the need to reforest large degraded forest areas often requires the use of mechanisation for certain tasks.

There are many problems associated with very large intensive monoculture plantations, which are especially difficult to manage in terms of their logistical requirements. Mixed species plantations also lead to more variability in the structure and composition of planted forests.

7.3 Dryland forests

Half of the world's livestock (e.g. camels, goats, sheep and zebu) lives in dry zones. Management of forests in such areas should take this into account and the practice of agro-silvo-pastoral systems would, therefore, appear to be most appropriate for the sustainable management of these areas.

7.3.1 Reconciling multiple uses

Measures to protect and restore the soil are essential, particularly in dryland areas prone to desertification. Forest production is only one aspect of agro-silvo-pastoral management, encompassing the production of wood, forage, fruit, etc.

Regulations to balance the utilisation of dryland forests by livestock with their productive capacity is essential and pasture management is a key element of integrated management of dryland forests. For example, there has to be equilibrium between tree and grass layers. Rangeland management should help to combat overgrowth and to maintain silvo-pastoral potential and livestock pressure should be adapted to forage stocks in both time and space.

Fire represents a key element in dryland forest management. Controlled burning at the beginning of the dry season is preferred to late seasonal fires, in order to promote the dynamics of wooded and grass vegetation. Given the context in which many of these forests are used (particularly in Africa), it is vital not to overlook the essential role of women in training and extension.

7.3.2 Simple silviculture

Silviculture should take into account the constraints placed on dryland forest management by physical, biological and social circumstances (e.g. the prevalence of drought and brush fires, extensive ranching, transhumance, etc.). Natural regeneration using techniques such as coppicing and/or the use of root suckers should be encouraged because the poor the water regime will lead to a natural advantage of vegetative reproduction over natural sexual reproduction. As a guide to which technique to employ, the forester should copy nature's examples and use sexual reproduction in favourable environmental conditions, or runners, coppicing and layering, in areas exposed to severe hydrological stress.

Enrichment is possible, and will have many of the same advantages as it does in humid tropical forests, but with one further drawback: it will increase potential vulnerability to fire passage even if fires are of a low intensity. Fire should be confined to open forest formations or tree or shrub savannahs, which are characterised by enough rainfall (at least 800 mm throughout the year) and where adequate maintenance and protection can be ensured.

Measures to protect fruit and forage species should be taken, such as control over pruning and stripping. In coppicing, the minimum-harvesting diameter should be between 6-8 cm, depending on the species. Rotation could be as short as 7 years to 14 years. The height at which trees can be harvested again will depend on the species. For industrial roundwood production, the minimum harvesting diameter will be between 30-35 cm, with rotations of about 20 years to 40 years or, in some cases, as much as between 50 years to 60 years.

7.4 Mangroves

Given their special nature, management of mangroves depends on the management of surrounding areas and, in particular, measures that affect and modify hydrological and coastal cycles and functions.

In view of this, the harvesting of forest products should be compatible with the other production functions of this ecosystem (e.g. game, fish, crustaceans, molluscs, apiculture and salt) and with protection functions (e.g. wildlife, plants and biodiversity). A minimum harvesting diameter of 15-18 cm should be used to maintain production and conservation functions in mangroves. The rotation period should be at least 10 years, but this will depend upon the species.

During harvesting, particular care should be taken in order to minimise damage to the soil and, at the same time, ensure natural regeneration. Seed bearing trees should be conserved if they are considered insufficient in the forest (i.e. less than 2,500 stems/ha of more than 30 cm in height). In the absence of natural regeneration, establishing plantations may be an appropriate option. Primary and secondary canals should be used to extract products and these should be carefully maintained. New canals should be less than 1.5 m in depth in order to limit soil degradation and erosion.

7.5 Protected areas

In protected areas, two main management activities should be given priority:

- identifying and managing areas that represent a variety of different ecological zones; and
- updating management plans on the one hand to achieve the objectives of maintaining biological diversity and on the other to best develop other uses of the resource, such as: hunting; wildlife viewing; ecotourism; and recreation.

8 CONCLUSION

Tropical forests cover much of the area located between the Tropics of Cancer and Capricorn and represent about 10% of the world's total surface area. Tropical forests constitute a delicate environment of paramount importance for the well being of the whole planet. They supply many useful products, including: wood; fruit; vegetables; mushrooms; medicines; oils; gums; resins; waxes; sweeteners; condiments; colourings; game; and recreation opportunities.

The biological diversity found in tropical forests far exceeds that of all other land ecosystems. These forests shelter at least 50% of all the world's animal and plant species, only a small proportion of which has been described and studied to date. These forests also play an essential role in climate regulation at local and global levels and maintaining global biophysical equilibrium, in particular by regulating water and carbon cycles.

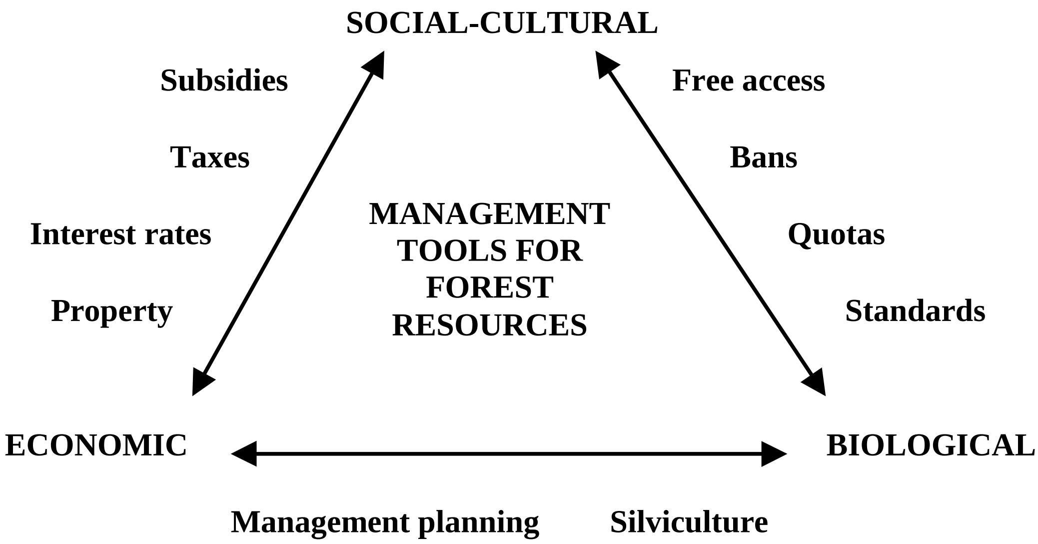
The underlying causes of the problems faced by tropical forests are complex, interrelated and, in many instances, occur due to factors outside the forestry sector. Causes include:

- overestimation of forest resources and underestimation of the benefits accruing from forest conversion;
- a lack of attention to the environmental and social costs of forest harvesting and clearing; and
- the real (or perceived) high risk and high cost of sustainable forest management.

Underlying causes also include subsidies that encourage forest conversion and population of uninhabited forest areas, road construction, structural adjustment and poverty alleviation programmes, land insecurity, underlying population pressure, political instability and policy failures at national and international levels. Many policies also tend to encourage the movement of people towards forest areas to improve livelihoods and encourage speculation and forest conversion. These multiple cause-effect relationships necessitate the development of inter-sectoral and interdisciplinary approaches to forest policy-making and management.

Sustainable forest management cannot be reduced to a merely scientific and technical debate. A global approach to sustainable forest management should take into account biological, socio-cultural and economic parameters as well. The creation of favourable institutional, economic and financial conditions is essential in order for the management of tropical forests to be sustainable. It is also necessary that all stakeholders have a constructive dialogue, to open up areas of ability and action outside their own specialisations and interest, in order to understand one another better and to find appropriate solutions to the permanently complex problems they encounter in managing tropical forests.

Figure 3: An example of some of the tools available to promote sustainable forest management



The tools for building this dialogue largely concern controlling access to resources and supervising forest production activities (see Figure 3). However, the broader issues should be discussed seriously and in a spirit of genuine partnership. Recognition of the role and responsibilities of all stakeholders is likely to offer the best guarantee for sustainable forest management.

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