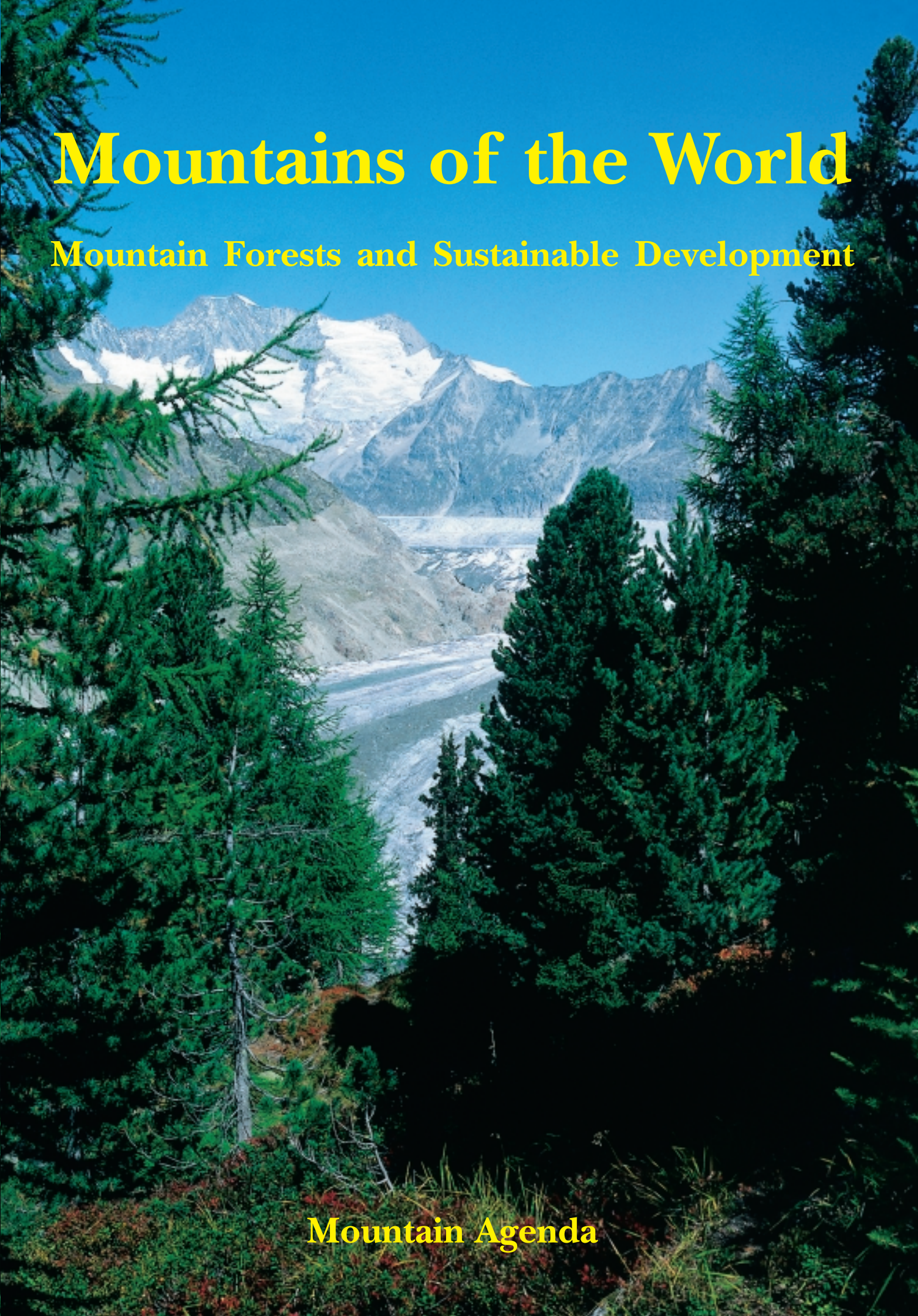
Mountains of the World

Mountain Forests and Sustainable Development



Mountain Agenda

Prepared for

The Commission on Sustainable Development (CSD) and its 2000 Spring Session

Prepared by Mountain Agenda

Mountain Agenda is an informal group of people with professional interests in sustainable mountain development, drawn from the academic and development co-operation communities. The group was created prior to the Rio Earth Summit (UN Conference on Environment and Development, 1992) to enhance the position of mountains on the global environmental agenda.

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Foreword

Forests are a source of hope. Twenty years ago, considerable areas in the hills of Nepal were largely deforested. According to forecasts made by the World Bank at that time, these forests – or what was left of them – would disappear entirely by the year 2000. It appeared that local people would no longer have a natural resource they could use as a sustainable basis of livelihood to enhance the quality of their lives. Today, 20 years later, forest cover in some of the same areas of Nepal is between 20 and 30%. In addition, there are local user groups who not only use forest resources but care for the forests as well. New ways to obtain economic benefits from the forests and process forest products have also been developed. This has created a basis of hope for considerably improving the quality of life of local people.

This random but very impressive example of the importance of forests is drawn from experience in a development co-operation partnership between Switzerland and Nepal. But we might well have taken an example from the Swiss Alps in the winter of 1998–99. The extraordinary avalanches and related disasters that occurred in this season dramatically demonstrated once again that daily life and survival – as well as economic conditions, transport, and tourism in mountain regions – depend in great measure on the many functions of forests.

This multiplicity of functions makes forests an obvious focal point of human concern. This is true not only for people who live in the immediate vicinity of mountain forests and demand much from them, but also for people in lowland areas. Fragile mountain forest environments are therefore subjected to great pressure that is too frequently reflected nowadays in non-sustainable and destructive exploitation.

The processes of forest degradation are manifold, extremely complex, and highly variable. The cumulative impacts of degradation on mountain forests are more significant and decisive than specific forms of degradation. Individuals or institutions acting alone are not in a position to assess these impacts and take successful measures to combat them. Therefore, the future and the well-being of mountain forests, as well as their sustainable use and protection, can no longer be the concern and the responsibility of individuals in a limited local context. Collaboration and complementary efforts on the part of many specialists in different fields will be required, along with efforts made by people who represent forests at the local, regional and global levels. Sustainable development of mountain forests in the 21st century will thus be an important task for the entire international community.

The present publication addresses the many causes and consequences of forest degradation in mountain regions, as well as promising measures that focus on forest protection and sustainable forest management. It is another in a series of reports that has now become an almost traditional contribution to the annual debates of the Commission on Sustainable Development (CSD). Its purpose is to shed light on links between the mountain development issues raised in Chapter 13 of Agenda 21, adopted at the Earth Summit in Rio de Janeiro in 1992, and the special themes that will be addressed at the CSD this year.

This report has both a theoretical and a practical purpose. It deals with approaches as well as ideas, and aims to introduce readers to the problems of forest degradation by presenting specific examples that are described and illustrated. But introducing issues and some knowledge of them is only a first step. The next step, involving commitment that leads to action, is the decisive one. In the final analysis, our actions will determine not only how progress in forest and mountain development is assessed, but also how we ourselves are judged. And the actions we take will determine in turn whether hope becomes a reality only for some of us or for all of humanity.

With these thoughts in mind, I recommend that this report make its way from readers' "heads" through their "hearts" to their "hands", to quote the Swiss educational reformer Heinrich Pestalozzi, who advised that an idea must first be understood, then taken to heart, and finally translated into action.

Walter Fust

Director, Swiss Agency
for Development and Cooperation

Many roles for mountain forests

In the United States, recreation and tourism accounted for 74.8%, or US$ 91 billion of the Forest Service's income from national forests - many of them in mountains. Timber sales provided only 2.7% of the Forest Service's income. (Figures for 1995, courtesy of E. Byers, The Mountain Institute)

In Laos, the state-controlled sale of wood products is the single most important source of foreign exchange, contributing over 30% of total foreign exchange earnings in 1993. Most of the country's forests are in mountain areas and are managed by slash-and-burn communities, which have come under increasing pressure from the timber industry. (Source: IMF-1993)

In Switzerland, the main aim of mountain forests is to provide public security against natural hazards (avalanches, rockfalls). The value of the protection provided by these forests has been estimated at US$ 3–4 billion per year. However, the protective function of many of these forests is threatened by low levels of use. (Swiss Agency for the Environment, Forests and Landscape, 1999)

Why forests and mountains?

During the 1990s, mountains received increasing attention on global agendas, starting with the inclusion of Chapter 13 – "Managing Fragile Ecosystems: Sustainable Mountain Development" – in Agenda 21, and moving towards the International Year of Mountains 2002. The global importance of mountains can be summarized in three statistics:

– they cover nearly a quarter of the Earth's land surface;
– they are home to about a tenth of the global population;
– they provide goods and services to at least half of humankind.

Of the world's forests, about a quarter are in mountain regions, as shown on the map that accompanies this document. Mountain forests play many key roles, contributing greatly to the value that mountains have for the global population.

Fresh water

Over half of humanity relies on fresh water from the mountains – for drinking, domestic use, irrigation, hydropower, industry, transportation, and fisheries. Mountain forests help to capture and store rainfall and moisture, maintain water quality, regulate river flow, and reduce erosion and downstream sedimentation.

Forest products

Mountain forests are important sources of wood and other forest products. Fuelwood from mountains is a major energy source in both the mountains and surrounding lowland areas, including towns. Cooking fires help heat homes and purify water – and thus improve standards of sanitation and health. Timber is important for construction and as a raw material for pulp and paper, for both local use and export. However, many mountain areas are subject to heavy and unsustainable logging and clearance for agriculture, for both subsistence and commercial use. These trends pose threats to the availability of non-wood products – fruits, mushrooms, and many other foods, as well as medicinal plants – which are often at least as important to local people as wood.

Carrying leaf fodder to feed livestock, Jarikot, Nepal. Forests are used in many different ways to help ensure the livelihoods of local people in an often harsh and inhospitable mountain environment. (U. Lutz)

The International Year of Mountains (IYM)

IYM 2002 was declared by the UN General Assembly in late 1998, with support from 130 countries.

Protection against natural hazards

Mountain forests are vitally important for protection against natural hazards such as landslides, avalanches, rockfalls, and floods. Many of these hazards also directly affect downstream areas. The protective function of mountain forests is important not only for people living in the mountains, but also for rail and road networks that link adjacent regions and population centres. Without protective forests, many mountain areas would not only become uninhabitable, but also too

dangerous as traffic and transit corridors. With the development of infrastructure, the protective role of mountain forests will increase in future, while the effects of air pollution and climate change may threaten this function.

Biodiversity

Mountains are hotspots of biodiversity. Mountain forests typically have higher biodiversity per unit area than adjacent lowland forests, and endemism is often high. This biodiversity is valuable to people in many ways. Plants and trees provide wood, fruits, and herbs for local consumption and use by local practitioners and the pharmaceutical industry. Forest biodiversity is threatened in mountain areas such as the Andes, the Mediterranean, and the Horn of Africa, where mountain forests have been reduced to a fraction of their original cover. In other mountain areas, largescale logging and the establishment of monoculture plantations are a serious threat to biodiversity.

Culture, amenity, and tourism

Tourism is the fastest growing global industry, and mountains are key tourism destinations in many parts of the world. Mountain forests, especially near urban areas, are experiencing growing levels of recreational use. A remarkably high proportion of the world's national parks and protected areas are in mountain regions, often without adequate compensation offered to local communities for restrictions on resource use. Natural forests contribute to the attractiveness of these areas and to the scenic beauty of mountain landscapes in general. They also have important cultural values in many regions.

Multifunctionality, a concept to reconcile the many roles of mountain forests

Mountain forests thus have many different functions and values. While production is the most widely accepted function of many mountain forests, security is often the most important service they provide – whether this relates to reliable supplies of water or food, or the protection of settlements and infrastructure against hazards.

Mount Revelstoke National Park, Canada. Mountain forests help keep snow in place to prevent hazards, release water slowly and evenly and in good quality, and add to the scenic beauty of mountain landscapes – an important asset for recreation and tourism. (M. Price)

To satisfy the many and often conflicting demands on forests, the interests of the different stakeholders must be carefully balanced. The protective functions must be weighed against the productive functions; the demands of downstream users (e.g., water, hydropower, timber) against the needs of mountain communities (e.g., fuelwood, non-timber products); the demands of short-term gains against the need for long-term sustained management. To achieve such balances, multifunctionality has become a key concept in mountain forest management. Central elements include the acceptance of the rights and knowledge of mountain communities, and the establishment of democratically legitimised institutions which support and arbitrate this local authority. The concept adopts a long-term perspective: mountain forests may be destroyed quickly, but need many years – or even decades – to recover.

This report addresses these key points by

- addressing key global issues related to mountain forests (pages 6–15)
- documenting local and regional experiences of mountain forest management from different parts of the world (pages 16–37)
- highlighting the need for new policies in mountain forest management (pages 38–39)
- presenting opportunities for sustainable mountain forestry, with concrete suggestions and recommendations for key stakeholders (pages 40–41)

The report is accompanied by **maps of the world's mountains**, and of **the world's mountain forests** (on one sheet).

Key issues in mountain forestry

Multifunctionality – a global concept for forest management

Mountain forests fulfil more functions, for a larger proportion of society, than forests in lowland areas. At the same time, mountain environments are often less hospitable for the growth and survival of forests, and the economics of mountain forestry are more uncertain. Addressing these challenges requires multifunctional approaches to ensure that the diverse demands on mountain forests can be met sustainably over the long term.

The merits of multifunctionality

The central theme of multifunctionality is to reconcile the interests of the many different stakeholders who derive products and benefits from mountain forests. This approach is not new; there are, and have been, many traditional systems through which mountain forests were managed jointly by their local communities. Such systems ensured that all members of a community derived similar benefits from their forests, and that levels of harvesting of wood and non-wood products (fruits, mushrooms, herbs, etc.) were sustainable. With the rise of scientific forestry from the late 18th century, the production of timber came to dominate forest management, being seen also as the keystone to providing other benefits from the forests. In mountain areas, this approach was often not appropriate for ensuring the protective function that many mountain communities had recognised for centuries through limitations on harvesting in carefully designated forests. Consequently, mountain forests were often divided into production and protection forests.

According to Hindu cosmology, the god Vishnu was born under a banyan tree *(Ficus bengalensis)*. It is forbidden to touch this tree with iron, and cutting its branches is said to bring harm to one's family – an example of the cultural importance of forests and trees. (Ch. Küchli)

Protective, productive, cultural and amenity functions

Today, it is recognised that mountain forests may have a range of functions relating to supplies of fresh water, production of wood and other products, conservation of biodiversity and wildlife habitat, protection against natural hazards, and also relating to culture and spirituality. The long-term provision of all these functions requires active management. For any mountain forest, the first stage of moving towards multifunctionality is to identify the different functions and stakeholders, and their interests. One basis for comparing the importance of the various functions is to estimate their relative values. However, this is not a simple process. While the economic value of timber, fuelwood, fruits, and other forest products can be estimated from market data, it is far harder to assess the value of reliable supplies of fresh water, protection against natural hazards, or recreational use; and almost impossible to value biodiversity, religious values, or mitigation of the impacts of climate change. Nevertheless, methods for making such estimates have been developed, and can provide useful information.

Left: Agroforests on the slopes of Kilimanjaro, near Arusha, Tanzania. In many tropical regions, mountain forests fulfil important productive roles in complex multi-story, multi-purpose systems of land use, which combine cash crops, products for home consumption, fodder, and wood for fuel and construction. Many of these tropical mountain forest areas are highly productive, but have come under increasing pressure from outside economic forces and population growth. (H.P. Liniger)

Right: Disentis in the Swiss Alps. Without protective forests, settlement and communication lines such as road, rail and power lines would be seriously threatened in mountain areas. The protective role of mountain forests, their single most important role in many mountains of the world, has long been known to local communities. (U. Lutz)

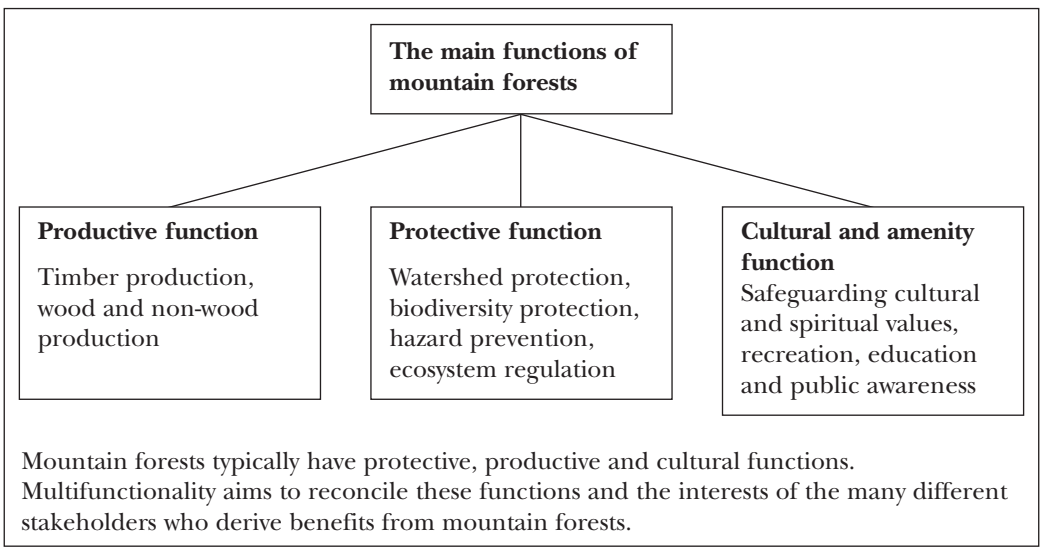
How multifunctionality works

Based on recognition of the various functions and stakeholders, multifunctionality aims to identify potential conflicts and resolve existing ones. This requires the involvement of all stakeholders in a long-term process of negotiation, policy definition, and implementation. Those responsible for this process must be fully trusted by all stakeholders. Local people must be included at least as equal partners with forest companies and representatives of government agencies. Often, special financial resources may have to be provided to forest users as well as owners to ensure that activities in the common interest are implemented, as successful implementation will depend on such support.
Every aspect of multifunctionality requires close cooperation and joint action between diverse stakeholders who may have worked together rarely, if at all – and may have been in conflict. These include timber companies; government agencies, which are often divided according to specific functions such as forest management and monitoring, road construction and maintenance, or avalanche or torrent control; NGOs with interests in biodiversity conservation or community development; and mountain communities, whose people typically vary greatly in terms of economic and political status and access to land.

Partnership between stakeholders

While multifunctionality needs to be promoted through appropriate laws and regulations, its success depends on the performance of partnerships among stakeholders. Within this context, mountain people need to be given an appropriate degree of control over the forests on which they depend, recognising that some activities may have to be constrained in the interests of a broader range of stakeholders, both in the mountains and downstream.

Martin Price and Thomas Kohler



Mountain forests typically have protective, productive and cultural functions. Multifunctionality aims to reconcile these functions and the interests of the many different stakeholders who derive benefits from mountain forests.

"Our entire life depends on forests. We get firewood from forests, wood for house construction, and also fodder for our cattle....
We get grass, leaves from trees, precious herbs and minerals for our animals. Forests also give us tea leaves, humus, fertiliser, and so on...." – Woman farmer, northern India

Managing international watersheds – the example of the Mekong River Commission: The mandate of the Commission is to promote sustainable management of the Mekong River, one of the world's largest international rivers. In an agreement signed in 1995, the four riparian signatory states – Cambodia, Lao PDR, Thailand, and Vietnam – agreed to "cooperate in all fields of sustainable development, utilisation, management and conservation of the water and related resources of the Mekong River Basin…" (Source: Mekong River Commission Annual Report 1997)

Mountain forests and the global freshwater crisis

More than half of humanity relies on the fresh water that accumulates in mountains – for drinking, domestic use, irrigation, hydropower, industry and transportation. Although mountain areas constitute a small proportion of river basins, they are the source of most of the river flows downstream. As demand for water resources increases, the potential for conflicts over the use of fresh water grows. Careful management of mountain water resources must become a global priority in a world moving towards a water crisis. Mountain forests help secure a balanced flow of water and maintain high-quality water.

Mountain forests, water quality, and water quantity

Without human interference, large tracts of mountain areas would be covered by forests. However, many mountain forests have been converted to other land uses: plantation forests, agricultural land, or grazing land. Human activities in these areas have both direct and indirect impacts on freshwater resources. Direct impacts result from direct use of water resources, or from pollution of these resources. Indirect impacts are caused by land use, which influences the way rainwater moves in the soil or over the land as well as the number of pollutants it collects on the way. The indirect impacts are much more difficult to identify and quantify – and thus to deal with – than the direct impacts, because of the complicated interactions of water with land, soil, and vegetation.

Intensification of land use can be observed in many mountain areas of the world and is frequently associated with destruction or degradation of natural forests. This increases the probability of negative effects on both the quality and the quantity of water. While the effects of mountain forests on water quantity are complex and not yet fully understood, there is strong evidence that water flow from forested areas is more balanced, with greater flow in dry seasons when water is most needed. Intensification of land use is very likely to have negative effects on water quality, largely due to erosion and pollution from agrochemicals.

Mountains – water towers of the world

Mountain areas constitute a small proportion of river basins, but provide most of the river flows downstream: 30-60 % of fresh water in humid areas; 70-95 % in semi-arid to arid environments. Careful management of mountain forests helps secure a balanced flow of water and maintain high-quality water.

Dams in mountains provide water for urban centres, industry, and irrigation in downstream areas. They also produce hydroelectricity, which can help reduce pressure on forests for fuelwood. Mountain forests have an important role to play in protecting watershed areas for dams in mountain areas. (Ch. Küchli)

An agenda for research

While folk tales and myths throughout the world illustrate that natural forests provide clean water, this role of natural forests has not often been properly documented, especially in comparison with other types of land use, and in relation to both indigenous and introduced soil and water conservation practices. Research is needed to clarify this role.

Provision of a balanced flow of good quality fresh water is one of the most important services of mountain forests. Annapurna Region, Nepal. (U. Lutz)

Another research challenge is to develop tools to support decision-making for proper water management. These tools should include methods for assessing water resources and modelling scenarios for alternative management options. Where international basins are concerned, there is an urgent need to standardise data and make them publicly available, and to exchange knowledge between neighbouring countries, from the mountains to the lowlands.

The shift from supply-side policies to water demand management

Fresh water has become a scarce resource in many parts of the world. Meanwhile, demand for domestic use, agriculture, hydropower generation, and industrial production continues to grow. In most dry areas, and increasingly in wetter regions of the world, the gap between supply and demand is increasing at an alarming rate. Both technical and political solutions must be sought in order to solve this fundamental problem.

Technical solutions offer a wide range of options for more efficient use of water. Large amounts of water can be saved by introducing more efficient irrigation systems, water harvesting and conservation techniques, water recycling systems in industry, and more careful use of water in private households.

However, *technology alone will not suffice: solutions must also be found on the political level.* Water policy is still dominated by a supply-side approach. As water becomes increasingly scarce, water policy must shift to *demand management*, to ensure equitable distribution between upstream and downstream users, between rural and urban areas, and between agriculture, industry, and other users. Policy must be based on a multi-level and multi-stakeholder approach which refers to specific basins or watersheds. Negotiation and mitigation of conflicting water uses are crucial policy aspects, and so are control and enforcement mechanisms supervised by legitimate institutions. Creating public awareness and informed decision-making based on hydrological, ecological, and socio-economic data are key factors in a water policy that focuses on demand management. Putting a price tag on water consumption will be indispensable in order to help reduce exploitative and wasteful use of water.

Mountain forests play an important role in providing a clean and adequate supply of water to mountain communities as well as to downstream areas. Mountain forests must be carefully managed in order to maintain their ability to provide the world with fresh water.

Hanspeter Liniger and Rolf Weingartner

Celebrating World Water Day in Nanyuki, Kenya, with Mount Kenya in the background. The mountain and its forests are the main providers of fresh water for the increasing population in the surrounding lowlands, supplying as much as 90% of the flow during the dry season. (H.P. Liniger)

Mountain forests and natural hazards

Mountains are dynamic, high-energy environments, characterised by uncertainty and danger. Mountain forests can play many roles in minimising risks posed by the various natural hazards that result from high rain- and snowfall, steep slopes, and significant variations in temperature. These risks are growing rapidly with increases in resident and visiting populations, intensification and diversification of land uses, and the expansion of urban and rural settlements, tourist resorts, powerplants and transmission lines, and rail and road systems.

Coffee plantation in the mountains of Costa Rica. Cleared from forestland, plantations such as these are highly susceptible to erosion, especially in the initial years of establishment, and will lead to deterioration of water quality and more unbalanced flow of water. (Ch. Küchli)

Where forest cover is missing, costly defence structures have to be erected to protect settlements and infrastructure from natural hazards such as avalanches and rockfalls. (SLF, Davos)

Mountain forests under stress

Mountain forests generally grow in challenging conditions, which include steep slopes, severe climates, and thin soils. Their trees are subject to many natural hazards: avalanches, rockfalls, landslides, floods, and high winds. All of these can damage individual trees or even entire forests, decreasing their ability to provide the protection function vital for people who live in and travel through the mountains. Added to these natural threats are those resulting from human actions, particularly air pollution and climate change. Air pollution may be from either nearby sources, such as transport corridors or industrial enterprises, or distant industrial agglomerations. Climate change will gradually alter the growing conditions for mountain trees, which could make them more vulnerable to natural hazards. These may also increase in frequency due to climate change.

The importance of diversity

The ability of a mountain forest to fulfil protective functions depends on both its position on a mountain slope and its type and condition; its structure, density, and health and the mixture of species and ages. To be resilient to natural hazards as well as pests and diseases, a forest should be composed of trees of different heights, ages and, as much as possible, species. Such a structure is found in some mountain forests but, especially where people have been living in the mountains, and using their forests for centuries, appropriate management is essential. Mountain communities have been well aware of the protective function of their forests and the need to reduce the area of forest development phases with low protective potential. This includes thinning young trees to foster the growth of

Mountain forests help restore damage inflicted by natural hazards. A landslide devastated this slope in Nepal's Dolakha District (photo on the left, taken in 1986). By 1995 (photo on the right), patches of forests and bush, replanted or established naturally, stabilised the lateral slopes of the torrent. (Ch. Küchli)

Just a few days before the start of the new millennium, parts of Europe witnessed heavier storms than ever before in the 20th century. France and Switzerland were particularly hard hit, including important sections of protective forests in the mountains. In a matter of hours, the storm felled 13 million m³ of wood in Switzerland – almost three times the sustainable annual yield of Swiss forests. Extreme events such as these – which could increase due to global warming and climate change – are a serious threat to the protective function of mountain forests.
Much of this huge amount of fallen timber will probably rot in the forests, as it is not worthwhile to process it at the low prices for wood products in today's deregulated timber market.

those that are left, and removing old and decaying trees which cannot withstand severe stresses – also providing space for new trees to grow.
Such management activities result in the production of wood that nowadays often has little market value. Where forests have been lost through natural disasters or air pollution, planting of new trees and the costly maintenance of new stands are necessary. Yet, while these activities may bring little if any economic benefit to forest owners, they are essential to provide services to the wider public. Consequently, financial support is required to pay for these vital activities. In some cases, this may come from mountain communities – for instance through a tax on tourism or on transit traffic, recognising that the necessary infrastructure is safeguarded by the forests. In most cases, support has to come from regional or national governments, to compensate mountain forest owners and managers for undertaking activities from which they derive no direct benefits, but which provide long-term security against catastrophes and the disruption of essential services for the benefit of mountain communities and downstream areas.

Hans Kienholz and Martin Price

"Flooding was not so serious when there were many trees in the mountains, not as serious as it is now." – Village women's director, China

Mountain forests – hotspots of biodiversity

The mountains of the world are hotspots of biodiversity. The centres of greatest biodiversity are in the tropics, including the eastern Andes, Costa Rica, Brazil's Atlantic forests, the eastern Himalaya-Yunnan region, northern Borneo, and Papua-New Guinea. Due to the altitudinal gradient, tropical mountain forests typically have more species in a smaller area than adjacent rainforests. For instance, in Ecuador, 17,000 km² of tropical cloud forest contain 3411 vascular plant species – 300 species more than in 70,000 km² of lowland Amazon forests. The total moss diversity for the five tropical Andean countries is estimated to be 7.5 times higher than for the entire Amazon basin.

Nearly half of UNESCO's Biosphere Reserves and a large proportion of its World Heritage Sites are in mountains. Among the case studies in this document, Mount Kenya (Kenya) and Huascarán (Peru) are both World Heritage Sites and Biosphere Reserves, Xishuangbanna (China) is a Biosphere Reserve, and the Tatras are a transborder Biosphere Reserve jointly inscribed by Poland and Slovakia.

Reasons for high biodiversity

One important reason that mountains – not only in the tropics, but also in mediterranean, temperate, and boreal regions – are biodiversity hotspots is that they include a high proportion of endemic species restricted to one mountain system – sometimes just one mountain. About half the Endemic Bird Areas are in mountain regions, particularly in tropical forests, and almost all the forest flora of mountainous Hawaii and New Caledonia are endemic. Reasons for high endemism include both the evolution of species which have been able to migrate along pathways created by newly-developed mountain ranges where speciation was stimulated by many open niches, and the interruption of pathways through mountain building and changes in climate. The isolation of many mountains after the last ice age is one reason for high endemism in many European mountains, where small populations of species survive in refuges providing suitable conditions.

Mount Kinabalu (4101 m) in Sabah is estimated to harbour over 4000 plant species, more than one-quarter of all the species in the United States of America.

The steepness and environmental complexity of mountains are also important factors in the high biodiversity of mountain forests. Vegetation patterns reflect environmental gradients, for instance from dry upper slopes to wet lower slopes with nutrient and debris accumulation. Landslides and avalanches disturb successional processes; different degrees of disturbance are characterised by different forest types. Contrasts between sites – for instance between those exposed to wind, sun, or frost, and those which provide shelter; or those with thin or deep soils – contribute to habitat differentiation. The varying geology of mountains is another factor in increasing biodiversity.

Patterns of biodiversity also vary with altitude. Upper montane forests tend to have a high diversity of species, but a low diversity of genera or families. Lower montane forests tend to have a high generic and family diversity. The type of predominating species varies from one part of the world to another. In the southern hemisphere, montane forests up to timberline are commonly composed of single species of old relict conifers or deciduous southern beeches. In the subtropics and warm temperate zone of the northern hemisphere, evergreen oaks dominate lower forests, and the upper forests are coniferous. Further north, lower mountain forests are

Mountain forest, Costa Rica. Tropical mountain forests typically have more species in a smaller area than adjacent lowland rainforests. (Ch. Küchli)

mainly deciduous (often oak and beech), and upper forests are coniferous, with very few genera. These forests also have rich populations of mosses and lichens. The most diverse forests outside the tropics in terms of their tree species are in Mediterranean areas. However, in terms of total numbers of plant and animal species, the richest mountain forests are in the tropics.

Biodiversity: a threatened asset

The biodiversity of mountain forests is valuable to people in a variety of ways. The range of plant and tree species provides diverse products, including wood, fruits, herbs, and mushrooms. In developing countries, the availability of such products is often assured by careful tending and planting over generations, contributing to the maintenance of biodiversity. The biodiversity of many mountain forests has been decreased through large-scale logging, followed by plantations of fast-growing species which provide wood for industries at the expense of other forest products; such trends began centuries ago in Europe, continued in Europe's American colonies, and in more recent decades in developing countries. However, because of the difficulties of access to mountain forests around the world, many still retain their natural characteristics and have therefore been designated as national parks or other types of nature reserves – of which many attract large numbers of tourists. In Europe, the oldest protected areas are forests – preserved both for their trees and as habitat for game to be hunted – while in developing countries, many biodiverse forests have been preserved for their sacred attributes by local people.

Gaps in knowledge

Knowledge of mountain forest biodiversity varies around the world. The flora and fauna of the European Alps, Japanese Alps, tropical Andes and Mount Kinabalu are well known; but those of the arctic and boreal mountains and some tropical areas are not. Efforts to increase this knowledge are important, to identify which species exist in which ecosystems, which are threatened, and how they are used; and to identify appropriate management strategies. The urgency is increasing, because mountain forests and their component species are likely to be significantly influenced by climate change.

Georg Grabherr and Martin Price

Many mountain forests have high levels of endemism – plant and animal species that occur nowhere else.

**Left: Pitcher plant *(Nepenthes),* a rare, insect-eating plant species found on boggy sites in Indonesian mountain forests.
(Ch. Küchli)**

**Right: The Giant Panda lives in mountain and upland forests in southern China. It is classed as endangered due to shrinking forest habitats.
(Still Pictures Putao)**

"There were so many indigenous trees, but all that has been lost. Now we see only eucalyptus plantations." – Ethiopian priest

**Researcher in mountain forest, Venezuela. Knowledge of mountain forest biodiversity is still lacking in many parts of the world.
(Ch. Küchli)**

The effects of climate change

Climate change will have significant impacts on the species of mountain forests and influence their ability to provide the many functions that are important to mountain people and hundreds of millions living downstream. Given the long lifetime of mountain trees, it is necessary to enhance our understanding of possible changes and start planning as soon as possible. This is particularly challenging because detailed predictions of future mountain climates are difficult, especially given the complexity of mountain terrain, the great variability of mountain climates, and insufficient long-term data about them.

Forest in Northern Thailand. Detailed and reliable predictions of future mountain climates are difficult – and so is an assessment of the impacts of climate change on mountain forests. (Ch. Küchli)

Changing climate – changing forests

Climate change is largely due to an increasing concentration of carbon dioxide in the atmosphere. This may be beneficial for the growth of trees, both directly and through increases in water use efficiency, permitting greater productivity in areas where water supplies are limited. Longer growing seasons are also likely to lead to increased productivity. In addition, the productivity of mountain trees and forests may be affected by changes in cloudiness and the frequency and timing of frosts, the competitive ability of tree and other plant species, and populations of pests and disease-causing organisms which thrive as temperatures increase. Equally, new climates may not be suitable for insects or birds needed for pollination, so that trees become unable to reproduce.

Compound effects of climate change, extreme events, and air pollution

One of the most critical effects of climate change in mountain areas is likely to be an increase in the number of extreme events, such as heavy snowfalls, major rainstorms, ice storms, and droughts. All of these may lead to major damage to mountain forests both directly and indirectly, for example through avalanches, floods, landslides, and fires. Such impacts will be of importance not only to those who depend directly on the forests for their livelihoods, but also for those living downstream and depending on the protection and welfare values of mountain watersheds. In industrialised countries, where mountain forest cover and density have often been increasing over recent decades, acid precipitation and climate change may combine to cause unpre-

Mountain forests: creeping upwards?

Recent research in the Simen Mountains National Park in Ethiopia, a UNESCO World Heritage Site, has shown that the upper treeline rose about 100 m in altitude within 30 years (1968 – 1997) – a result of climate change? Worldwide, natural high-altitude treelines occur at surprisingly similar growing season temperatures (mean temperatures from 5.5 to 7.5°C), whereas season length varies from 2.5 to 12 months, and many other climatic constraints show considerable regional variation. Therefore, global warming has a great potential to shift treelines above current altitudes. But whether the growth of trees at the treeline will benefit directly from the CO_2 increase in the atmosphere is still an open question.

dictable and dramatic impacts. New scenarios may be required for risk mitigation and disaster preparedness.

As temperatures and precipitation patterns change, each species will respond individually. Consequently, the mountain forests of the future are unlikely to look like today's. Some species will be able to survive and reproduce in the future climates of the sites where they now live; others will not – but could prosper elsewhere if they can be planted in time. An increasing number of trees are likely to be endangered, damaged, or killed by pests, diseases or fire; appropriate methods of sanitation logging will be needed to remove these. Shortened rotations may be desirable to reduce exposure to changing conditions, modify genetic diversity, and meet local needs for wood. Both forestry companies and local mountain people need to consider such long-term issues when choosing which species to plant and harvest.

Overall, increases in temperature may allow trees to grow at higher altitudes than at present or in the recent past. Consequently, it may be possible to extend the treeline upwards – as long as soils are suitable. Particularly in developing countries, the expansion of mountain forests is being discussed with regard not only to answering the needs of mountain people and protecting watersheds, but also to the storage of carbon as a response to climate change. However, trees should not be planted purely as a policy response to a global issue without considering the needs of local people and the likely impacts of changing land use, for instance from grazing land to plantation. The need to store carbon and minimise energy use may also be a stimulus to increasing attention to wood-based construction.

The need for action

Changes in land use deriving from economic and political forces, air pollution, and climate change will lead to major changes in the world's mountain forests in the long run. To respond to these major forces of change, governments, industry, and society must work together to reduce air pollution and to support the research needed to develop better understanding for predicting the behaviour of mountain forest ecosystems, species, pests, and diseases; inventory methodologies which consider regeneration as well as future harvests; and appropriate management strategies, including genetic conservation and breeding.

Martin Price

Oil well in Ecuador. Burning of fossil fuels for industry and transportation is one of the main causes of human-induced climate change. (Still Pictures R. Scott)

Research in the Canadian Rocky Mountains has shown a 10 to 100-fold increase in organochlorine compounds, including toxic industrial pollutants and agrochemical pesticides, at altitudes between 770 m and 3100 m, which is the result of long-range atmospheric transport from urbanised and agro-industrialised areas. Air pollution has impacts on mountains and their forests, even if they are seemingly pristine and located far away from centres of human activity. This pollution can reduce the vitality of forests – a problem known in many mountain regions in the world. (Source: adapted from Blais et al., 1998, in *Nature* 395)

Below: Forest killed by acid rain, Karkonocze National Park, Poland. (Still Pictures A. Maslennikow)

Local and regional experience

Southern Kyrgyzstan

Collaborative management of walnut-fruit forests

The walnut-fruit forests of southern Kyrgyzstan are the country's most valuable forests. After centuries of exploitation, they have been reduced from 1,500,000 to less than 30,000 hectares. These represent the world's last extensive natural stands of a number of fruit-bearing species that are cultivated and marketed globally: most notably, walnut, pistachio, almond, apple, pear, and wild plum. They also serve as an important source of local people's livelihoods. Collaborative forest management (CFM) is now being introduced with the aim of achieving more sustainable use of these valuable forests.

The increasing pressure on forest resources

Since Kyrgyzstan declared independence from the former Soviet Union in 1991, it has undergone radical political, social and economic changes, causing considerable hardship. Two immediate effects on the environment and, in particular, the forest sector are apparent. One is that long-term investment in the protection and sustainable use of natural resources cannot be a priority for government spending when the immediate needs of its population are so pressing. The other is that the resources themselves are under increasing pressure, given that subsidised forms of energy for heating and cooking are no longer available and, with a massive rise in unemployment, people are turning to alternative means of gaining a livelihood. These include clearing land for agriculture, and the exploitation of forest products, both legal and illegal.

Forest management is the responsibility of State collective forest farms or *leshozes*, of which there are 14 in the walnut-fruit forest area. These *leshozes* have been subject to drastic recent cuts in state subsidies, and no longer have the staff numbers or funds to function as they did in the past. Forest management approaches must now be adapted to the new political and social situation.

At present, a few people collect rose hips from the walnut-fruit forests for sale to pharmacies, but with greater quality control, better prices could be fetched. There is also potential for making rose hip jam. (J. Carter)

The multiple functions of the walnut-fruit forests

The multiple functions of the walnut-fruit forests need to be recognised in management strategies. For biodiversity conservation, they have an outstanding function as a pool of naturally-occurring germplasm of internationally valuable, commercial species. Environmentally, they play vital roles in protecting catchments of both local and regional significance; the Syr-Daria and Amu-Daria rivers which flow from them drain into the threatened Aral sea. From a productive perspective, the forests provide a wide range of products, contributing to both government revenue and local household economies.

Collaborative forest management (CFM) was introduced to Kyrgyzstan as a working partnership between the key stakeholders in the management of a given forest – in particular the immediate, local users and the relevant forest authorities. While this is a radical divergence from past, highly top-down management practices, the government has embraced CFM in its new forest policy.

Mountain landscape in southern Kyrgyzstan. Walnut-fruit forests can be seen in the middle ground. (J. Carter)

Collaborative forest management: a new concept

A new, more collaborative approach to management is being introduced in the walnut-fruit forests, beginning with leasing state forest land to local people. The tenants, who may be a family or groups of families, are contractually required to manage and protect a forest plot in return for the right to harvest and sell its non-timber forest products. Given its lack of funds for forestry, the government has interpreted collaborative forest management (CFM) as a means of mobilising free labour for tree planting and forest protection. However, this is not the true meaning behind the concept, and it is now recognised that local people need to gain clear benefits from forestry activities, and that their rights, as well as responsibilities, must be fully considered.

Much effort has been put into promoting equity in distribution and contractual obligations relating to CFM leases. Forest leases are not a new concept; seasonal leases, just giving harvesting rights (mainly for walnuts) have been issued by *leshozes* for many years. However, the concept of taking long-term responsibility for forest management – for 5 years or more – in return for harvesting rights is new. Initially, the *leshozes* tended to demand too much of prospective tenants, who readily agreed to demands that they could not fulfil. Already experience is indicating to both parties what can realistically be expected, and tenants have demonstrated both knowledge and willingness in conducting activities such as tree planting and maintenance as part of their lease agreements. It is also clear that the benefits of CFM to tenants will be maximised if they work together.

After 70 years of Soviet rule, many Kyrgyz distrust collective action – at least if it is imposed. However, people do still work together in traditional, voluntary self-help groups. These might provide a precedent on which to build collaborative forest management.

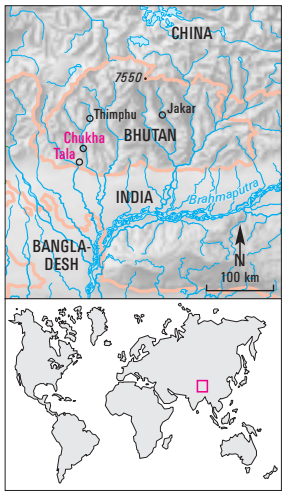
The challenges ahead

Possibilities for developing other sustainable sources of forest-based income generation are also being investigated. This is particularly important in years when the rather variable walnut harvest is poor. The large-scale manufacture of low-quality goods is no longer appropriate due to competition with foreign products; new processing and marketing strategies must be radically different. Options for cottage industry production of goods tailored to local and regional market demand are being tested.

It is not yet certain that local people have sufficiently widespread interest to enter into lease agreements which entail considerable labour input. However, forest-based income generation and responsible forest management are clearly integrally linked, and both need to be supported.

Jane Carter, Esther Haldimann, Marat Kamytov

Gender sensitivity in project activities has not proved easy in the male-dominated profession of forestry. However, specific attempts to seek out and act upon the views of women have been made, as in this PRA exercise. (J. Carter)



The mountains of Bhutan

Forests, conservation, and hydropower

Bhutan has some of the highest levels of forest cover and biodiversity in the world. The Bhutanese spare no effort in trying to maintain and protect this treasure. The land-locked kingdom in the eastern Himalayas is often seen as a model for proactive conservation. Geographic isolation, low population density, delayed modernisation, stable leadership, and the traditional reverence for nature, enhanced by the Buddhist worldview, have all contributed towards preserving this rich and diverse environment. Today, popular support for conservation is increasingly driven by the realisation that healthy forest and grassland systems are the prerequisites for optimal benefits from hydropower.

A wealth of forests

Forests cover over 60% of Bhutan, changing with increasing altitude from subtropical to warm broad-leaved forest, chir pine, cool broad-leaved, evergreen oak, blue pine, spruce, hemlock, fir, juniper/rhododendron and dry alpine scrub. The tree limit is usually at 4000–4500 m. The forests support much of the country's biodiversity: 160 species of mammals, 770 of birds, and 5400 of vascular plants. A significant proportion of the forests are almost inaccessible primary forests, unique for the region and the world.

Forest management: from irrigation to power generation

In the traditional subsistence economy, the availability of irrigation water for rice and other agricultural production was the main factor in the prosperity of farming households. Farmers used ingenious systems of earthen and wooden channels to bring the water from small streams over long distances and rugged terrain to irrigate their fields. Forests continue to play crucial roles in maintaining soil fertility in an environment with otherwise poor soils. Bhutan's cautious and conservation-oriented leadership has succeeded in enhancing the traditional respect for nature and conservation. Policies and legislation, as well as the media and the education system, have raised the level of awareness and appreciation for an intact environment. The first modern legislation was the 1969 Forest Act. This specifically aimed at protecting the forests, and has

"..we can draw much satisfaction from our success in the preservation of our natural environment, which has become an outstanding example for the rest of the world"

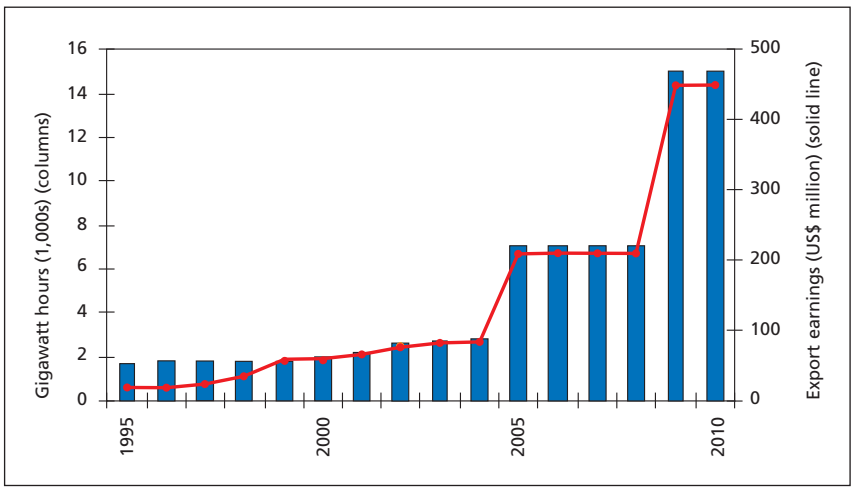
His Majesty the King of Bhutan, 1999.

Left: Lay novice with offerings for the deities in a Buddhist ceremony. Traditional beliefs and customs, which are still observed today, emphasize respect for nature. (W. Roder)

Right: Diversion dam of the Chukha hydropower station. With about half of Bhutan's territory lying above 3000 m, the potential for hydropower generation is enormous. (W. Roder)

Forests and guardian spirits

A strong emphasis on watershed management is apparent in both Buddhist and pre-Buddhist rituals that are observed to this day in Bhutan. Nature is home to guardian spirits who reside under trees, in rocks, in the soil, and in rivers and lakes. Mutual respect and harmony must be maintained for the well-being of both human and guardian spirits. The practice of re-planting of trees as *shingtshab* (tree replacement) for trees which have been removed is often part of the rituals to appease the spirits.



Above: Current and projected hydropower generation and export earnings. Electricity from hydropower is Bhutan's single most important export item, sold exclusively to India. (Source: Royal Government of Bhutan, 1998)

Left: Ploughing terraced rice fields. The value of water for hydropower generation is fast becoming more important than for agricultural production. For both uses, sustainable management of watersheds, including their forests, is essential. (W. Roder)

resulted in increases in forest cover and quality. The recent policies of decentralising executive power to the lowest level possible, together with the Social Forestry Act (1996), will make rural households responsible for the management and conservation of forest resources.

Prospects for hydropower

The traditional irrigation systems are still appreciated, but the value of water for hydropower is fast becoming more important than its value for agricultural production. With the commissioning of the Chukha Hydro Power Station, generating 336 MW, power became the single most important export item. When the Tala Hydropower Station comes into production in 2005, it is expected that electricity generation will overtake agriculture in its contribution to the Gross National Product. As 45% of Bhutan has an elevation above 3000 m, the potential for hydropower is enormous: 30,000 MW could be generated, sufficient to cover 60% of India's current requirements. Currently, India is the only purchaser of electricity generated from hydropower, and the Bhutanese government is well aware of the one-sided dependency created by this path of development. Most of the hydropower plants are based on the run-of-the river system which takes advantage of the natural drop of the rivers. However, the silt load of the water is a major concern. The benefits from hydropower can only be realised if the vegetation in the watershed areas is preserved or improved. Forests play a crucial role in this respect.

Walter Roder

Woman farmer milking yak on a winter morning. Agriculture is the main occupation of the vast majority of Bhutanese people. (W. Roder)

Central Sumatra, Indonesia:

Agroforests, enhanced production, and biodiversity conservation

Kerinci is a high valley in Central Sumatra, approximately 80 km long and 10 km wide, with a large flat floor. Much of the valley is included within Kerinci Seblat National Park, Indonesia's largest national park, 60% of which is forested. Kerinci's population is about 300,000, of whom 90% depend on agriculture. The great diversity of forest types, due to the great variation in altitude (300–3805 m), makes the area, in which the densely inhabited valley is an enclave, a major sanctuary for many endangered species. A locally developed type of agroforestry, *pelak*, has great potential for fulfilling the needs of the local populations and for preserving biodiversity.

Vanishing forests

As in most of Sumatra, forest conversion is an important issue, though its rate is difficult to assess. Since the 1960s, cultivation of cash crops such as cloves, coffee and cinnamon has expanded very quickly. As a result, both land sales and forest encroachment have increased. From 1985 to 1990, cinnamon production increased by 145%: deforestation was often brutal, frequently by workers migrating from neighbouring poorer areas and contracted by rich, local landholders.

Right: Irrigated rice fields. The current intensification of rice cultivation is supported by the relatively low labour input needed for the management of *pelak* tree gardens. Mount Kerinci (3805 m), a moderately active vulcano and the highest mountain of western Indonesia, can be seen in the distance. (B. Sansonnens)

Locally developed agroforests as an alternative to forest destruction

Some villages contrast greatly with this sad image. One is Jujun, with 3000 inhabitants and a territory of 1530 ha, from Kerinci lake and the adjacent paddy fields up to steep slopes covered by well-preserved forests. Dense tree gardens, or agroforests, locally known as *pelak*, cover much of this area. The complex structure and composition of these man-made ecosystems, found under different names over much of Sumatra and throughout Indonesia, make them look remarkably like forests. However, *pelak* have a different structure from natural forests, with two layers of mature trees, instead of three, that let light easily reach the ground and allow a productive shrub layer, such as coffee trees. This structure also favours the quick growth of replacement trees that farmers manage through careful individual selection.

Left: Land use in Jujun, Kerinci valley: irrigated rice fields in the foreground; the village surrounded by *pelak* tree gardens, followed by open field cultivation *(ladang)* on the lower end of the steeper slopes, which may later develop into *pelak*. The forest covering the upper slopes belongs to Kerinci Seblat National Park. (B. Sansonnens)

Combining cash crops, timber, and a great diversity of other products

In Jujun, as throughout Kerinci, cinnamon is the main crop, but it is just one among other crops, and one among many other species, either cultivated or spontaneously growing. Cinnamon trees may be harvested from the age of five years; the tree is felled to collect the bark and then sprouts readily. Although bark production is higher when the trees are grown without cover, cinnamon is shade-tolerant and may be grown in the understorey. Thus, cinnamon trees make up one layer of gardens where, for instance, coffee trees may be harvested once a year, and rubber trees tapped once a day. As the quantity of bark increases with age, a farmer may wait until he needs cash, his trees acting as living capital. This flexibility allows him to choose among various patterns of cultural associations, rotation periods, and plantation densities.

Apart from these major market commodities, five main trees are key components of Jujun's *pelak* agroforests: *jengkol*, a small fast-growing tree whose seeds are important in the local diet; *kemiri*, a tree that grows up to 30 m which regenerates naturally and yields nuts of commercial value; and three fast-growing timber species that originate in local forests. Many other trees, including various fruit trees, are planted, selected or cared for by farmers according to their needs or market fluctuations. More than 100 species with specific uses are relatively common in Jujun gardens. They need little maintenance; weeds are rapidly shaded out and fertility is conserved, due to the good protection of the soil against erosion and the fact that little is removed through harvesting. Labour inputs are low and allow a very flexible schedule, since only fruit trees have peak harvesting periods.

The merits of the *pelak* agroforestry system developed by local farmers

Pelak tree gardens or agroforests ensure many functions that were formerly provided by forests: economic functions, with products both for local consumption and for sale (timber, fruits, spices, bamboos); social (free access to wild medicinal plants, tree seedlings); symbolic (traditional representations and beliefs); and ecological (soil conservation and restoration, pest control) functions.

Agroforests help solve the problem of land shortage

Since topography limits further encroachment on the forests, land shortage is becoming a major constraint in Jujun, requiring the intensification of land use. Improved rice varieties are increasingly cultivated in paddy fields. As these require a much larger labour input, farmers lack time to grow annual vegetables on the open plots where they used to plant cinnamon, which eventually remained the only growth for 10–20 years *(ladang)*. This land-consuming cyclic system is now giving place to new *pelak* where all production is mixed. The farmers implement rural afforestation as a response to land constraints and economic adaptation.

Such trends may occur elsewhere, as land constraints are likely throughout the area. New facilities already make complex gardens more profitable: fruits are now easily exported to other areas, in or outside the valley. Yet real promotion of agroforests implies further commercialisation. Due to the depletion of forest resources, locally grown timber could acquire an enhanced value and reach outside markets.

Potential for buffer zone management

The fact that *pelak* agroforests have been developed locally, and their remarkable adaptability to farmers' needs, suggest good potential for their wider application. They fit well with the concept of buffer zones, which are favoured by donors and have been discussed for a long time in Kerinci, as in many other forested tropical national parks.

Bertrand Sansonnens, Yildiz Aumeeruddy

Pelak **are dense multistoried tree gardens. Typically, a combination of cash crops (cinnamon, coffee), timber and fruit trees, and a wide range of other useful species are grown with a relatively low labour input.** ***Pelak*** **gardens are important genetic reservoirs for biodiversity, especially in areas where pristine forests are vanishing. (B. Sansonnens)**

Timber, mainly for home consumption but also increasingly for sale, is a major component of ***pelak*** **gardens. Like cinnamon, timber represents a stock of living capital, which can be converted to cash when necessary (marriage, pilgrimage to Mecca). (B. Sansonnens)**

Southern China

Swidden gain, swidden loss: Akha land use in upland Yunnan

The Akha have lived in Yunnan in southwest China for over two millennia, and in Xishuangbanna for over 500 years. Until well into the 20th century, swidden farming, or shifting cultivation, was their most important way of farming. However, this did not mean indiscriminate felling of trees. Protected forests were kept around each village to keep out evil spirits. Customary rules also forbade cutting anything in a cemetery forest or watershed protection forest. Using simple tools, villagers could cut trees elsewhere for subsistence needs and, until the 1940s, primary forest covered the mountains. After the Chinese Revolution of 1949, the Akha, like other minority peoples, automatically became citizens of the New China, and have subsequently participated in all of China's political changes.

Some villagers still open swiddens for shifting cultivation, as much to grow vegetables as to produce upland rice. (J. Sturgeon)

The age of communes and collectivisation

In 1958, the Akha in Xishuangbanna were organised into production teams within large communes. The production teams produced grain for the state in huge swiddens, larger than ever before. After upland rice was planted for a year or two, the fields were fallowed for 13 to 15 years, regenerating into forests with fertile soils. However, during the collective period, which lasted into the early 1980s, levels of state grain procurement were at times so high that villagers had too little to eat.

Thailand: Unresolved conflicts between upland people and the state

All forest land in Thailand, including areas in the north inhabited by so-called "hill tribes," belongs to the Royal Forestry Department (RFD). Some hill groups had migrated into the north centuries ago from China and Burma, some groups more recently as a result of violence in north-eastern Burma. Since the RFD sees forests as state assets, the Thai government has come to no real accommodation with these forest-dependent peoples, calling them "squatters" on Thai territory and "destroyers" of the forest. This includes the Akha, similar to those living in China. Most of these "hill tribe" people are not citizens of Thailand, and have no legal rights to the land they manage. The landscape of northern Thailand (see photo) reflects the unresolved conflict between the purposes of upland villagers and those of the state.

Landscape in northern Thailand, characterised by many swiddens (areas of shifting cultivation) and little forest. Conflicts between the interests of upland people and the state relating to land use are a major hindrance to development and environmental protection. (J. Sturgeon)

"Without swiddens and regenerating forests, many of the plants I use to cure people and livestock may disappear " – Old Akha woman

Changing policies: property rights, perennial crops, and wet rice production

To promote agricultural productivity, national policies in the 1980s devolved property rights and land management to the household level throughout China. In Xishuangbanna, communal land, including wet rice fields, tea fields, stands of bamboo, shifting cultivation land, and freehold forest plots for fuelwood, was distributed to households. Villages received community forests, where villagers cut trees for houses. From the early 1980s, extension efforts encouraged planting cash crops and perennials in swiddens to contribute to growing markets. Gradually, the extension of perennials, as well as increasing emphasis on wet rice cultivation, is bringing an end to the practice of shifting cultivation. Policymakers see shifting cultivation as degrading to the environment, even though in this area, most forest loss has resulted from state policies pushing villagers to produce more grain in the days of the communes. In some places, tin has been discovered, and has become a major source of household income.

The issue of shifting cultivation

In 1996, the authorities declared that by the year 2000, villagers must reduce swiddening to two *mu* (ca. 0.2 ha) per person. However, some people continue to open up small areas for upland rice or corn each year in order to maintain their livelihood options – particularly if tin is mined out or markets change. They also realise that, with no swiddens and regenerating forests, many of the hundreds of tree and plant species may be lost.
Chinese policymakers have heeded international advice claiming that shifting cultivation destroys the environment. While under some conditions this may be true, it is not in Xishuangbanna. The villages have been drawn into markets, to sell their vegetables and bamboo to buy radios and TVs. But the new landscape with more monoculture cash crops will have less biodiversity. Chinese policies are succeeding in integrating mountain villagers into the 'socialist market economy', and have done so more smoothly than some of China's Southeast Asian neighbours. But there is a price to pay, as the plants and trees produced by regenerating swiddens are no longer available – and almost all of these have not only economic, but also medicinal uses.

Janet Sturgeon

Economic alternatives reduce shifting cultivation

Many households in Xishuangbanna have already reduced the area under shifting cultivation or abandoned swiddening altogether – thanks to economic alternatives. These alternatives include wet rice production, production of perennial crops for the market, and off-farm employment. Being Chinese citizens, Akha can work in government offices, schools, banks, and run private businesses. Many young Akha complete high school and college.

Mountains and minority people

Yunnan Province, where Xishuangbanna is located, borders on Burma, Laos, and Vietnam. There are 55 official minority nationalities in China, comprising about 7% of the population. Yunnan is home to 26 minority peoples. Many of these, including the Akha, live in the uplands of this mountainous province in southwestern China.

Above: An area of natural forest in Xishuangbanna. Local communities have protected this forest for over 200 years to conserve the abundant rattan that grows there. (J. Sturgeon)

Below: The upland landscape of Xishuangbanna at about 1600 m. Villages are nestled at the foot of the hills, with community forests on the slopes and wet rice on the plain. (J. Sturgeon)

British Columbia, Canada

New approaches in managing temperate rainforests

Public expectations for resource stewardship of the temperate rainforests of coastal British Columbia are changing. In response, new strategies include replacing clearcutting with variable retention harvesting, reserving more old growth forests through landscape zoning, and achieving independent forest certification.

Every year, over 400 cm of precipitation fall on the temperate rainforests of the mountains of Vancouver Island and Canada's west coast. While clearcutting has long been the dominant harvest method, both this and old growth conservation have been persistent social concerns for many years. In 1997, one of the region's largest forestry companies began a comprehensive review of its forest policies.

A bid to reconcile conservation, employment, and shareholder value

A project team developed options to enable the company to meet three specific objectives: to ensure employee safety is not compromised; to become North America's most respected forest company; and to find solutions to forest issues that would enhance shareholder value through improved market access and earnings. In 1998, the team recommended the company:

- replace clearcutting by 2004 with variable retention, a more ecologically-based approach to harvesting and silvicultural systems;
- increase conservation of old growth forest by defining broad management objectives for landscape zones;
- achieve independent forest certification.

The company committed itself to implementing this programme. The goal of retaining more old growth forests, yet with neutral impact on employment and costs, will be met by conserving them in more contiguous, undeveloped areas. Commercial timber production will concentrate on second growth and significantly logged old growth areas in ways that emphasize economic margin rather than harvest volume. Already, experience

Decaying wood provides important habitat for cavity nesting birds and other organisms. Traditional silviculture eliminates much of this structure from commercial forests. (G. Fischer)

Typical old growth forest conditions include trees of varying species, age, size and canopy height. (A. Inselberg)

suggests that additional costs can be offset through technological innovation and improved performance.

Defining area-specific management objectives by landscape zoning

Three stewardship zones are being established, each with a different management emphasis and goal for stand and landscape retention. The *Old Growth Zone* comprises 10% of the land base, with the primary objective of conserving old growth forests; management plans reserve 70% of the original forest. Harvesting will use uneven-aged systems, and openings will be less than one hectare. The *Habitat Zone* comprises 25% of the land base, with the primary objective of wildlife conservation; 40% of the original forest will be retained. The *Timber Zone* comprises the remaining 65% of the forests. While commercial production is emphasized, variable retention will be applied, and about 28% of the original forest will be retained.

Variable retention: following nature's model

Variable retention is an approach to silvicultural systems and harvesting in which structural elements of existing stands are retained to achieve specific objectives. Variable retention follows nature's model, recognizing the role of structural complexity for forest ecosystem function and biological diversity. Living and dead trees of varying sizes and canopy layers, and large woody debris, are retained as habitat for a host of organisms. Variable retention can be implemented at different scales within many harvesting systems, and can be combined with traditional silvicultural systems, such as shelterwood or selection, to meet forest regeneration objectives. The specific objectives are to:

- retain late-successional forest structures to enrich the diversity of second growth stands, enhance habitat connectivity over the landscape, and provide 'lifeboats' for survival and dispersal of species after harvesting;
- create opportunities to match harvesting with market demand without high-grading, or compromising forest health, vigour, genetics or timber quality;
- match different retention and silvicultural systems to site-specific regeneration and wildlife needs; and
- meet social expectations of stewardship and visual aesthetics.

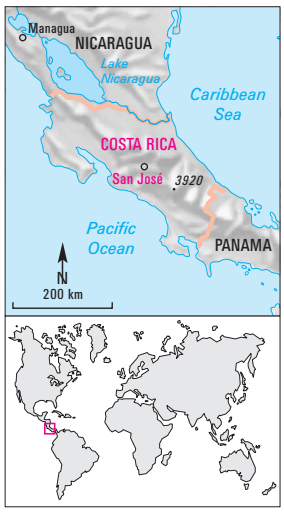
An example of variable retention with 20% of the original forest retained as groups and individual trees. No part of the area is more than two tree lengths from standing trees. (W. Beese)

Validation and certification

An adaptive management, monitoring, and research programme is being developed to support this new approach, involving company biologists and academic and government scientists. A group of international scientists is convened annually to provide a critique and advice on implementation. The company is also seeking independent certification under several systems.

Glen Dunsworth and Bill Beese

Harvesting patterns on Vancouver Island from regenerated large clearcuts (lower right) and smaller recent clearcuts (upper right). (G. Fischer)



The mountains of Costa Rica

Compensation for environmental services from mountain forests

One of the most important innovations of Costa Rica's 1996 Forestry Law was the decision to compensate forest owners for the environmental services their forests provide to society. This system, the *Payment for Environmental Services*, is supported by a tax on fossil fuels. In recognition of the fact that urban authorities, hydroelectric corporations, and irrigation projects usually use the hydrologic resource of mountain watersheds without acknowledging this service, new proposals have been put forward for financing the system, such as including the cost of watershed management in the cost of hydroelectricity and drinking water supply. Several studies have shown that Costa Ricans are willing to pay for these costs in order to maintain the ecological functions and environmental services derived from forest ecosystems, particularly mountain forests.

An effective way to compensate private forest owners

The main assumption underlying payment for environmental services is that forests would be better maintained and protected if forest owners were compensated for the services that their forests provide. Forests cover about 40% of Costa Rica's territory; 60% of these are private forests. In the past, one problem in implementing sustainable management practices was that, although these have benefits to society, forest owners received very few of these benefits. In this respect, payment for environmental services is an effective way to capture these benefits and transfer them to forest owners. Moreover, Costa Rica cannot afford to establish and manage more national parks and protected areas in order to guarantee the specific environmental services of mountain forests.

How the compensation system works

The compensation system is managed by the National Fund of Forest Financing of Costa Rica, which is in charge of collecting

Environmental services acknowledged by Costa Rica's 1996 Forestry Law:

- Uptake of greenhouse gases from the atmosphere
- Biodiversity protection
- Watershed protection
- Protection of natural scenic beauty.

Land use type	*Total amount paid (US$ per ha)*	*Annual payments as percentage of total for years 1–5*				
		1	*2*	*3*	*4*	*5*
Reforestation (tree planting)	518	50	20	15	10	5
Management of natural forest	316	50	20	10	10	10
Forest conservation or natural revegetation of deforested areas	202	20	20	20	20	20

Amount paid for environmental services for each forestry land use type, December 1999 (Compilation: José J. Campos)

Costa Rica's mountain forests: A key asset for the country

Costa Rica's mountain forests contribute to the generation of about one-third of the country's electricity and almost half of its drinking water.
Furthermore, these forests offer habitat for many species of flora and fauna, such as the resplendent quetzal, a tropical bird that is a preferred photo target for many of the hundreds of thousands of tourists who visit the country every year.

resources and paying the beneficiaries for the environmental services. Funds come mainly from two sources: a selective tax on consumption of fuels and other hydrocarbons, and international payments for environmental services of global value.
The National Fund has been able to negotiate payment for watershed services with several hydroelectric corporations. The first was *Compañía Energía Global*, which owns two hydroelectric projects in the Central Volcanic Range of Costa Rica. This company acknowledges the payment of watershed services to forest owners in two watersheds. On average, the company pays US$10/ha/year and the funds are disbursed by the National Fund, along with the Foundation for the Development of the Central Volcanic Range. Another company to join this initiative was *Compañía Nacional de Fuerza y Luz*, which agreed to pay up to US$40/ha/year in a hydroelectric project in the Aranjuez river watershed in the Tilarán Range. Studies show that the value of this watershed service varies from US$5/ha/year to US$70/ha/year. The sums fixed for the payment for watershed services in Costa Rica have resulted from negotiations between the National Fund and the corporations; they are a balance between the willingness to pay, and the importance of the forests for the protection of the hydrological resource.

The establishment of a world ecomarket

Encouraged by this positive experience, the National Fund and the Government of Costa Rica have been negotiating the establishment of the world's first ecomarkets, with the support of the World Bank and other major donors. The aim is to promote the development of markets for environmental services from private forests. This would foster the protection of biodiversity in large areas of private forest located mainly in buffer zones of the protected areas of Costa Rica, in habitat corridors, and in hydrologically important watersheds.

Funds originating from Costa Rica

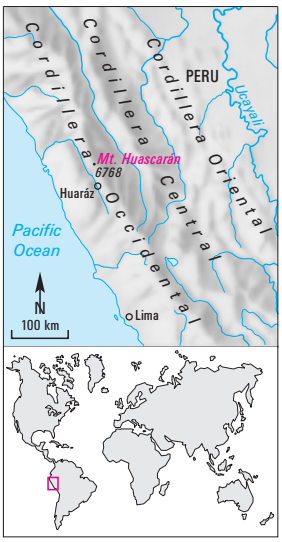
In 1997, US$14 million was paid out for environmental services, which resulted in the reforestation of 6500 ha, the sustainable management of 10,000 ha of natural forests, and the preservation of 79,000 ha of private natural forests. Eighty percent of this funding originated nationally; the other 20% was generated by the international sale of carbon fixation services under the "Clean Development Mechanism".

José J. Campos and Julio C. Calvo

Left: A mountain forest composed mainly of large oak trees. This type of forest, sometimes also referred to as cloud forest, can contain more than 300 species of epiphytes on only 4 hectares. (F. Solano, CATIE)

Above: Costa Rica's mountain forests provide important habitats for many plant and animal species – such as the resplendent quetzal. (R. Seitre/WWF/BIOS)

Buena Vista Peak, at 3400 m. The mountain forms the water divide between the Atlantic and the Pacific Oceans. The forest and its upper treeline at about 3000 m can be seen in the middle ground. The forest protects a watershed which is important for the provision of fresh water to San José, Costa Rica's capital, and for the generation of hydroelectricity, and was therefore given national park status in late 1999. (F. Solano, CATIE)



The understory of *Polylepis* forests has edible brushes in addition to pastures, thus serving as a "forage bank" for animals during the dry season. The understory also contains many plants used in traditional medicine by local women. Local populations have a stake in conserving these forests as long as they have access to the benefits they create. (R. Arevalo)

Andes, Peru

Managing the world's highest forests

Peru's Huascarán National Park protects some of the most important remnants of the Andes' high-altitude quenual *(Polylepis spp.)* forests. This remarkable tree grows at higher altitudes than any other tree in the world – to just below the snow line at 5000 m. Like many other national parks, Huascarán National Park is surrounded by traditional communities that claim ancestral rights to the resources inside its borders. Consequently, relationships between peasant communities and Park administration were tense and difficult at the time of its creation in 1975, but have since improved considerably.

An unwritten pact...

Over its 30 years of existence, the administration of this Park has had few resources to manage it, much less to invest money in community development. The Park's authority rests in a long, often hidden, history of peasant-state relations. Representing Peru's central government, the Park has created an unwritten 'pact' with peasant communities, by which local people are granted access to the Park's grasslands as long as they agree to organize in user committees that perform a series of obligations. These include the requirement to plant a few thousand seedlings of *Polylepis* every year. No systematic study has been conducted on the rate of survival of this investment based on community labour, yet casual observations suggest that it is low. Yet peasants dutifully continue to plant the *Polylepis* they produce in their nurseries, year after year, fulfilling their part of the pact.

Park and forest management: written and unwritten obligations

Obligations of local user committees
- Perform an annual roundup of cattle to keep track of animals
- Maintain number of herds within limits negotiated with the park
- Maintain nurseries of native tree species
- Provide labour for reforestation of native tree species
- Support the park with information concerning non-legal uses of the area

Obligations of the park
- Participate in roundups and keep track of animals
- Provide technical support for tree nursery production
- Perform (informal) functions of the state, mostly in relation to local conflict resolution.

...and its historical roots

A historical perspective on the *Polylepis* forests, now protected by the Park, sheds light on the cultural and political origins of the hidden social norms that underlie the relationships between Park and people. In the early 1600s, a few decades after the Spanish conquest, the Jesuit priest, Father Bernabé Cobo, noted that the Spaniards found extensive, well-preserved, mountain forests, because the Indians took only what was strictly needed. Yet the forests did not last long after the Spanish conquest, as they became an important source of fuelwood for growing cities.

This use of the forests was linked to the government system that the Spanish Crown established in the Americas, based on the notion that they ruled over two separate

'Republics': the Republic of Spaniards and the Republic of Indians. The political relationship between the Spanish rulers and their Indian subjects can be described as a 'Colonial Pact'. By paying tributes to the king, Indians were granted certain political and economic rights, gaining a degree of independence as a separate 'Republic'. Historical evidence, dating back to the 18th century, indicates that Indian groups claimed that their payment of tributes gave them the right to use the *Polylepis* forests, grasslands, lakes, and glaciers of what, centuries later, became Huascarán National Park. In colonial times, this mountain area was *ejido*, or commons – areas of open access subject to use under certain regulations. Access to *Polylepis* forests, for the collection of firewood, was most important to Indians because it was their main source of cash to pay their tribute to the Spanish Crown, and therefore to keep their rights of access to land and other resources.

From peasant uprising to agrarian reform

The birth of Peru as an independent nation in 1821 witnessed the enclosure of the commons and the birth of Creole *haciendas* or land states in the Huascarán region. While Indians continued to pay their 'Indian Tax', the state did not protect their access to their commons, and thus, in their eyes, broke the pact. This may have been the origin of the 40-year long *Atusparia* peasant uprising in the 1840s, one of the bloodiest in Peru's history. A century later, in 1969, the Peruvian state declared an Agrarian Reform that expropriated the *haciendas* that privatised the Indians' commons in colonial times, and declared these lands a national park.

Improved park and people relationship for the benefit of forests

Thus *Polylepis*, this seemingly wild tree of the high Andes, has been an important resource for local people and at the centre of past political battles. Tracking the colonial history of these forests helps in understanding current relationships between the Park and the local people. Planting *Polylepis* every year, communities who surround the Park pay a 'tax' that grants them access to grassland resources – even if the effort to regenerate forests is wasted. This example shows that any successful attempt to conserve or reconstruct forest landscapes in the Andes must recognize their historical and political dimensions, and their anthropogenic nature as much as their ecological foundations.

Jorge Recharte

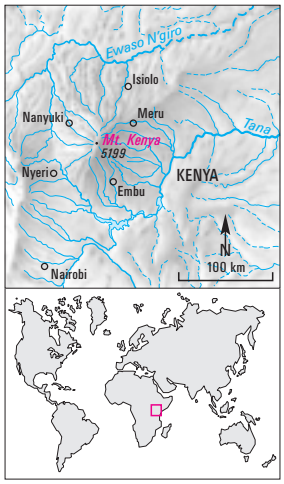
Polylepis forests are still a mystery to science. It is not known why they grow higher above sea level than any other tree in the world. These forests are a refuge for birds, wild animals, and wild relatives of domesticated crops.

Human interference and the ecology of *Polylepis* forests

- It is estimated that present distribution of *Polylepis* in Peru represents 2% of the original cover. *Polylepis* forests changed over the last 10,000 years with human induced fires, the domestication of animals such as the llama and the alpaca, and major climatic events.
- A recent study of *Polylepis* in Huascarán National Park shows that areas with some grazing pressure are as diverse as those that are less or not affected by human use. The same study found that in a small forest patch there were 130 plant species, representing 17% of all those found in the entire Park.
- A strategy to recover *Polylepis* by fostering natural restoration instead of afforestation might be a more effective approach to conservation.

Above: *Polylepis* tree just below a glacier in Huascarán National Park, growing among rocks that create a favourable microclimate at this high altitude of close to 5000 m. (TMI – Peru)

Left: Nowadays, *Polylepis* remnants show as small patches. Some scientists suggest that *Polylepis* was the natural vegetation type of high-mountain areas in Peru and Bolivia until 10,000 years ago. Open rangelands were probably created by humans burning these forests to graze their animals. (R. Arevalo)



Six species of large mammals of international conservation interest live within the forest area of Mount Kenya, including elephant, black rhinoceros, and leopard.

The highlands of Kenya

The threatened forests of Mount Kenya

The solitary extinct volcano of Mount Kenya rises to 5199 m on the Equator, 180 km north of Nairobi. Mount Kenya has a rich biological diversity in terms of ecosystems and species. In 1997, Mount Kenya National Park and the surrounding natural forests were listed as a World Heritage Site. The mountain forest plays a crucial role in preserving Kenya's main watersheds. The mountain is an important tourist destination. Its forests are, however, threatened by extensive pressure.

Mount Kenya is one of Kenya's main 'water towers' – the catchment for the Tana and Ewaso N'giro rivers. The forest is crucial for preservation of these watersheds. The Tana is Kenya's largest river, supplying water to over five million people, and to the country's main hydropower stations and major irrigation schemes. The Ewaso N'giro is the main river crossing the semi-arid Laikipia plateau and the Samburu plains and deserts.

The mountain's scenery is highly appreciated by tourists, attracting both domestic and international visitors, including climbers, walkers, bird-watchers, and fishermen. During 1996–97, 14,000 people visited the National Park, 30% from overseas. The various groups of people living around Mount Kenya attribute several cultural values to its forests, which provide important locations for religious and other rituals. Many tree species are considered sacred and used in various ways.

A history of extensive use of mountain forest resources

The Forest Department has the primary responsibility for managing the indigenous forests and forest plantations in the forest reserves and for providing extension services. As the forest reserves are adjacent to the National Park, the Forest Department works closely with the Kenya Wildlife Service in managing the forests. The major concerns with regard to the management of the forest reserves relate to the main forest practices: logging of indigenous trees, charcoal production, forest plantation, and livestock grazing.

In the past, licences were issued for logging indigenous trees in various parts of the forest reserves. By 1986, the exploitation of indigenous trees had reached a critical level. Consequently, the government instituted measures to bring logging under control, including ending forest operations on Mount Kenya and culminating in the countrywide 1986 Presidential ban on the exploitation of indigenous trees. Charcoal production is banned inside forest reserves owing to the fire risk it presents to ecosystems and the destruction of the tree cover associated with traditional methods.

Mount Kenya is ***"one of the most impressive landscapes of Eastern Africa with its rugged glacier-clad summits, Afro-alpine moor lands and diverse forests, which illustrate outstanding ecological processes"***

World Heritage Committee, 1997

Right: Harvesting coffee in the high-potential agricultural zone adjacent to Mount Kenya forest. High, and increasing, population density and lack of alternatives to farming are two of the main reasons for increasing pressure on forestlands. (T. Kohler)

Forest plantations have largely been established through the inter-cropping of tree seedlings with annual agricultural crops. In this form of agroforestry, agricultural crops should be phased out in the third year of tree growth, when the tree canopy usually overshadows their normal growth. The 'farmer' would then have to move out of the allocated plot and would be eligible for another plot, if available.

Grazing is legally allowed in the forests, as it enables suppression of weeds in forest plantations, facilitating faster growth of young trees, and reducing biomass that could pose fire hazards in the dry seasons. However, grazing is detrimental in young plantations, particularly during the first three to four years. In the past, the government has been forced to suspend grazing once it has got out of hand because the rules and regulations have been ignored.

Mount Kenya forest with Mount Kenya (5199 m) in the background. This part of the forest, situated along the main tourist route to the mountain, was included in the National Park to preserve its pristine character. (T. Kohler)

Achievements and problems of sustainable forest management

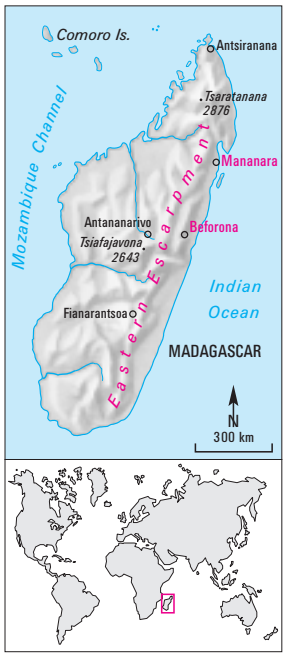
As a response to increasing public outcry regarding the wanton destruction of Mount Kenya's indigenous forests, a systematic aerial survey was implemented in 1999. This showed that the forests are heavily impacted by illegal activities in all areas below the high-altitude forest belt. Most of the broad-leaved mixed forests are undergoing serious destruction through extensive illegal logging of camphor, cedar, and olive trees. Illegal cultivation of marijuana was found more than 21 km into the forests. Over 75% of the clearcut plantations have not been replanted with trees, and the fragmented forests surrounding and between the plantation areas are heavily impacted by human activities. Large-scale charcoal production was found close to the main towns and other rural settlements. Encroachment for crop production has decimated thousands of hectares of natural forest. The extensive destruction of the forests has negative long-term impacts: disrupting wildlife habitat, destroying biodiversity, impairing water catchment and micro-climate regulation, and retarding forest sector development. The root causes of the destruction of these forests are the lack of economic alternatives for a growing population, inappropriate institutional arrangements, insufficient financial resources, and lack of good forest management.

Large tracts of Mount Kenya forest are heavily impacted by human activities. (P. Pestalozzi)

The need for institutional restructuring and law enforcement

Following the aerial survey, a new ban was issued on all non-subsistence activities in Mount Kenya's forests. Institutional restructuring, including the strengthening of co-operation between the Forest Department and Kenya Wildlife Service, has also been initiated to help bring illegal activities under control and ensure the implementation of the ban.

Christian Lambrechts



Per capita forest cover

Between 1980 and 1995, per capita forest cover in Madagascar decreased from 1.95 to 0.9 ha. Per capita forest cover in the United States is 0.77 ha, in Switzerland 0.15 ha, and in Great Britain 0.04 ha. (All figures for 1995. Source: World Resources 1998-1999, World Resources Institute/UNEP/UNDP/World Bank)

Primary forest dynamics on the eastern escarpment of Madagascar. (P. Messerli, from: Green and Sussmann, IUCN, FAO, UNEP, and other sources)

The eastern escarpment of Madagascar

Tropical mountain forests – myths and realities of conservation and development

Madagascar is one of the world's hotspots of biodiversity: 150,000 of its 200,000 species can be found nowhere else. In contrast to this 'biological wealth' is a very significant human-induced degradation of natural resources. Malagasy forests have experienced a rapid decline. The unique tropical rainforests on the hills of the eastern escarpment have declined even more dramatically. In 1950, the primary forest was still two-thirds of the cover found 1500 years ago. By 1985, another third had vanished, mainly due to slash-and-burn cultivation practised by an estimated 120,000 households living on the margins of the forest, as well as immigrants moving in from more degraded areas.

Farmers practice slash-and-burn cultivation mainly for upland rice, transforming primary forest into secondary forest and fallow vegetation. Increasing population densities caused fallow periods to shorten to 3–5 years, leading to decreases in soil fertility and fallow vegetation, both critical for production. Productivity is therefore decreasing rapidly, leading to the impoverishment of peasant households. Struggling for short-term food security and survival, smallholders are unable to intensify land use and therefore thus cultivate new land.

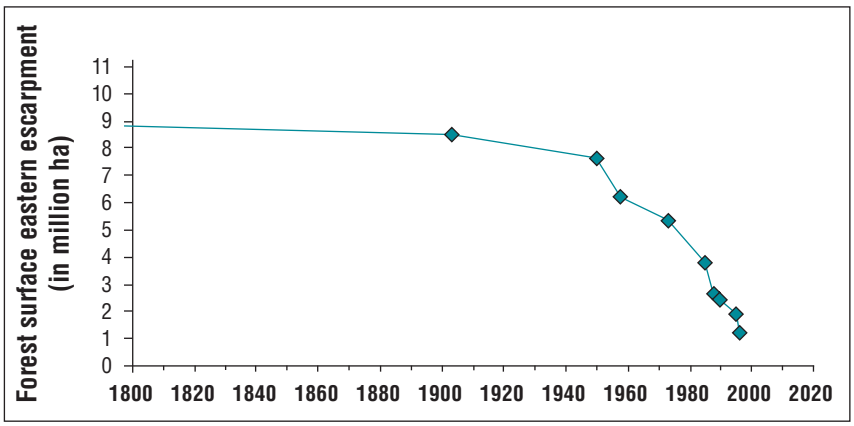
The external view of slash-and-burn

The ongoing degradation of Madagascar's forests is attracting the interest and concern of more and more external actors. The government worries about issues such as the nation's ability to produce enough food, and the impact on foreign exchange when food imports become necessary and exports are used up. International concerns focus on global warming and declining biodiversity, both of which are linked to the vanishing forests. Many of Madagascar's plants are highly valued for medicinal and biotechnological purposes.

Such interests and concerns have often led to conservation-oriented development proposals that do not adequately recognise the situation and needs of farmers. Slash-and-burn farmers continue to be held responsible for deforestation, degradation, low productivity, and low technology adaptation. Accordingly, recommended external solutions aim at sensitising them to the long-term benefits of conservation and setting up rules and repressive measures.

The farmers' situation

The local people's well-being is tied to the natural resource base, used for food, medicine, and fuel. Slash-and-burn cannot merely be considered as production activity; it also represents a way of venerating ancestors. Local people clearly perceive land degradation as a threat. Productivity of upland rice has decreased to 2.5 kg of rice per day of labour invested, while households continue to invest 40% of their overall time in this activity. Complementary activities are more profitable. One day invested in irrigated rice yields 4 kg of rice; one day invested in traditional agroforestry cash-cropping (fruit, coffee and bananas) allows the purchase of 12 kg of rice. There are several reasons why peasants continue to practice slash-and-burn (see box, p. 33 top left). However, traditional slash-and-burn systems are challenged by population growth and could collapse. Thus,



A farmer's view on the advantages of upland rice production *(tavy)*:

"Already our ancestors grew *tavy* – it is our way of life. In contrast to irrigated rice, many other things can be grown together with *tavy* such as maize, vegetables, beans, spices, and so on. *Tavy* fields are far less vulnerable to the frequent storms than irrigated rice....It is very important to burn the vegetation before seeding. It would be too much work to clean the fields of the vegetation. Unburned vegetation would attract rats and other animals, which ravage the rice. The ashes fertilise the soil. The more vegetation is burnt, the better the yields. Fire is very important to destroy the harmful insects and to fight weeds. Nowadays however....as fallow land becomes scarce, the advantages of fire are lost. Yields are low and labour increasing. Households spend almost half of their time for upland rice cultivation. That's also why we have little time to look after the fruit gardens, to establish irrigated rice fields, let alone to attend ceremonies and help other families. Even though *tavy* has become very difficult, we feel that it is still the safest way to produce enough food."

reconverting traditional systems is not a development option. New pathways that represent viable alternatives for local people are needed.

rural development will allow the enhancement and creation of more intensive production units and the stabilisation of land use.

Peter Messerli

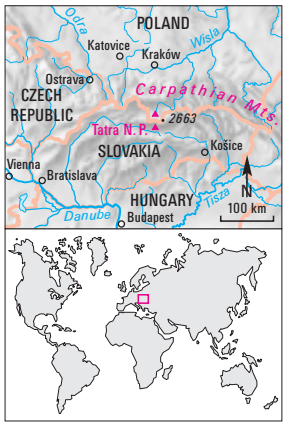
How to produce more – and more sustainably?

Madagascar's population will double in the next 25 years, no matter how successful family planning programs are. Land use will not only have to become more sustainable, but will also have to produce twice as much food as now. Agricultural production will thus have to undergo serious structural transformations. The destiny of Madagascar's mountain forests and biodiversity will depend on the success of these transformations.
Smallholder land management decisions will play a key role. Improvements must focus on key factors which influence these decisions. Priority must be given to socio–economic and organisational factors: marketing networks, communication and infrastructure, credits, land access. National conservation and development policies must be re-examined in order to set clear and realistic priorities and improve implementation.
The remaining forests are vanishing rapidly and the progressing degradation entails a continuous loss of future land use options. To implement coping strategies rapidly, the national and international value of preserving Madagascar's forests must be capitalised upon. Only significant investments in

Improved marketing conditions can enhance sustainability of land use. This can be shown by the example of the Mananara region (see map p. 32), where farmers concentrate on cash crops (clove and vanilla) and slash-and-burn cultivation is less important. Rice has increasingly been cultivated under irrigation as a complementary crop. This system is now threatened by low prices for rice.
(P. Messerli)

Home gardens have a great potential for intensification and are a more sustainable form of land use. Mainly coffee and banana are grown, but also a great diversity of other fruit trees. They absorb only 16% of total household labour investments, but provide as much as 75% of household income.

Left: Slash-and-burn cultivation near Beforona on the eastern escarpment of Madagascar. Different stages of the cultivation cycle can clearly be distinguished in the picture.
(P. Messerli)



Western Carpathians, Slovakia

Human influences in the Tatra National Park forests

Located in the Tatra Mountains of the northern Carpathians, Tatra National Park (TANAP) is Slovakia's oldest national park. It was established in 1949 and its area is 74,111 ha, including a protection zone of 36,574 ha around the core of the National Park. Forests cover about 60% of its area; the predominant forest tree species are Norway spruce at lower altitudes and mountain dwarf pine near the treeline. The forest has been subject to air pollution for decades, and, more recently, to the effects of climate change.

Some areas within the forests of the Tatra National Park are popular sites for summer and winter tourism. View across Lake Štrbské. (M. Saniga)

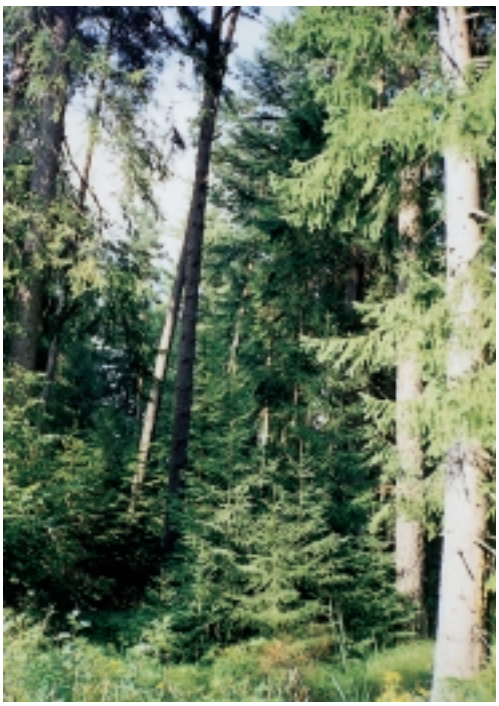
Extensive forest use in recent centuries

In recent centuries, two thirds of TANAP's forests were substantially affected by human activities: planned logging and the afforestation of numerous large clearcuts carried out after natural catastrophes, especially those caused by wind. The rest of the forests, especially at the upper treeline and in inaccessible places, remained natural. The most valuable forest ecosystems are now nature reserves, which comprise 34% of TANAP's area. These are mostly montane and subalpine spruce forests, which developed the traits of virgin forests through long-term processes. Today, these are the ecologically most stable forests, with successful natural regeneration and a diverse structure. As nature reserves, they are preserved to allow only natural processes to take place, without silvicultural or exploitation intervention.

The problems of air pollution and its impact on the forests in the Tatra Mountains have been systematically investigated since 1989. The measurements confirmed the supposed high concentration of sulphur dioxide. Changes in climate such as extremely warm summers and deficits in rainfall, as well as increasing concentrations of ozone, all contribute to the weakening of the forests.

Air pollution, a new threat to forests

Apart from its sister national park across the border in Poland, TANAP is surrounded by cultural landscapes, some of which have been intensely used in past and present. The park is therefore exposed to many anthropogenic influences. The problems of air pollution and its impact on the forests have been systematically investigated since 1989. The very first measurements confirmed the supposed high concentration of sulphur dioxide: around 20 micrograms per m^3. This pollution originated from industrial agglomerations in Silesia, the Krakow region of Poland, and the industrial region of Ostrava in the Czech Republic. Pollution by solid particulates is not serious and does not exceed the limit of 2 micrograms per m^3. Most of TANAP is moderately endangered by pollution, with the highest loads in the Belian Tatra Mountains in the months of June and December.



spread but non-indigenous spruce forests. Once these have been completely destroyed, the succession of pioneer tree species – particularly mountain ash – begins.

Area-specific forest management: autoregulation, selective felling, understanding forest ecosystems

Knowledge of the influences on, and changes in, the forests has forced the park rangers to regulate their development through silvicultural measures which follow natural principles and allow the forests' functions to be achieved. Protected forests account for 63% of the forest area, and 37% are special-purpose forests. A shelterwood system (promoting regrowth in areas with reduced canopy cover) is used on 60-70% of the area of silviculturally managed forests; 20-30% of the area is managed using a selection system for cutting trees. Purpose-oriented selection, a transitional system between single-tree and group selection systems, is applied in the remaining 10-20% of the area. Decisions about the type and implementation of silvicultural measures are based on objective evaluation of the autoregulation capacity of each forest ecosystem and its functions.
The greatest need in forest management is to understand the synergetic effects between the different factors adversely affecting the forest ecosystems – in order to increase their stability through integrated forest protection – and the use of efficient and ecologically-oriented management techniques.

Milan Saniga

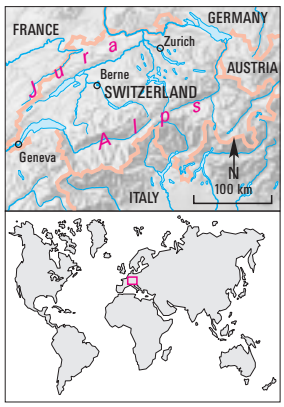
**Top left: Natural regeneration of silver fir and Norway spruce, High Tatra National Park.
(M. Saniga)**

**Below left: Forest heavily affected by bark beetle in the Kotlový Źlab Nature Reserve, West Tatra Mountains. Pests such as the bark beetle often affect forests weakened by stress factors, including changes in climate and air pollution.
(M. Saniga)**

Changing climate, weakening forests

Changes in the climate have also contributed considerably to the weakening of the ecosystems of the High Tatras. The ecological stability of the forest ecosystems has been negatively influenced by both decreases in precipitation and extremely warm summers. Climatic extremes such as droughts and precipitation deficit, high ozone concentration, and high levels of deposition of sulphur and nitrogen seriously endanger the forests' stability and physiological vitality. Their high susceptibility is also related to the predominant soil types, especially at higher altitudes over 1100 m, and their stability is further affected by wind, snow, and icing. Weakening of the forests is frequently followed by bark beetle epidemics, especially in the wide-

**High Tatra Mountains, Slovakia, showing the forest belt and Končistá Peak (2537 m) in the background. The forests of the Tatra mountains are surrounded by cultural landscapes, some of which have been intensely used in past and present; the forests have therefore been exposed to many anthropogenic influences.
(P. Fleischer)**



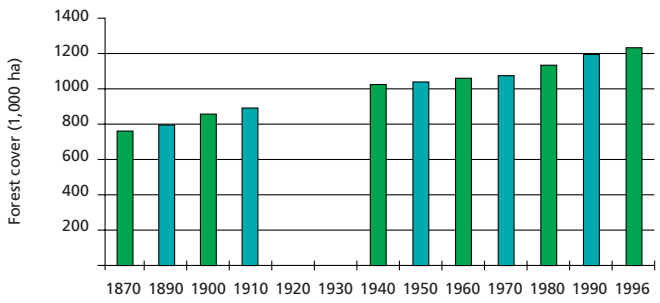
The Alps, Switzerland

New trends in mountain forest policy

70–80% of Switzerland's forests are mountain forests. For centuries, their fate has been influenced by the needs of downstream urban populations. Concern about the catastrophic state of mountain forests and a series of natural disasters provided the main impetus for a common federal forest policy in the late 19th century, with the aim of conserving the spatial extent and geographical distribution of forests. The history of the mountain forests reflects the fundamental socio-economic and political changes that have taken place in Switzerland over the last 200 years.

Until the 1860s, mountain forests were heavily used as a source of timber and fuelwood for surrounding lowland areas. The town of Berne, now the capital of Switzerland, required enormous quantities of wood for cooking and heating. Wood was also exported down the large rivers, for instance to build the port of Antwerp in Belgium. Part of the wood needed to meet these demands was obtained by clearcutting forests in the Bernese Alps. Yet people living in the Alps had a great demand for leaves for fodder and litter for subsistence farming. These patterns of resource use produced fundamental conflicts of interest – and put heavy pressures on the mountain forests.

Switzerland's total forest area has increased by 60% in the last 150 years



Most of the increase in forest area was in the Alps, mainly on abandoned agricultural land. This creates problems regarding both landscape and regional planning and economic development. Strict conservation of the forest area should no longer be the predominant task of mountain forest policy. It must be complemented by other strategies and instruments. One possible new approach could be the replacement of a strict sectoral view by a holistic policy of intersectoral land use planning and management.

The industrial revolution reduces pressure on mountain forests

The intense pressure on the Alpine forests was substantially reduced in the second half of the 19th century, due to railway construction, coal imports, and industrialisation. The first train arrived in Berne in 1858. Two years later, coal could be purchased more cheaply than fuelwood, and began to replace wood as an energy source. New jobs were created at railway nodes, and many rural people migrated to the growing towns. Age-old conflicts over mountain forests began to disappear.

The reduction of pressure on forest resources made possible the separation of agriculture and silviculture. Foresters were able to concentrate on timber production and on building up protective forests. Yet, over the same period, a number of catastrophic landslides and floods still occurred in the Alps, and their impacts were felt downstream. These disasters were linked with the earlier clearcutting to supply urban demands. The disasters provided the main impetus for the first federal forestry law, which came into force in 1876. Subsidies were provided to finance a forestry service and undertake torrent control and afforestation. The forests expanded in area, and forestry continued to develop as an economic sector. In numerous mountain communities, timber revenues provided a substantial portion of the budget.

From industrial to post-industrial society

In the 1950s, cheap petroleum became readily available. An industrial society was transformed into a modern consumer society. As the Alps became a global destination for

tourism and recreation, more and more people, properties, and infrastructure were exposed to natural hazards. A winter of disastrous avalanches in 1950–51 and subsequent demands for greater security resulted in increasing subsidies for protective forestry and for building structures to prevent avalanches. In the late 1980s, a new forest policy was developed. Recognising the importance of public security, the Swiss government now pays up to 70% of the costs of tending the forests, and the cantons and communes (regional and local governments) pay most of the rest.

Public funds for securing the protective functions of mountain forests

In Switzerland, costs for managing mountain forests are three times higher than for lowland forests. Even if reduced to a minimum, they will never be covered by the revenues from forest products. Mountain forests are mainly protective forests; ensuring public security is their main purpose. To compensate forest owners for the provision of this non-marketable good, the Swiss government paid CHF 40–50 million (ca. US$ 25–35 million) per annum in recent years in indemnities for tending measures in protective forests.

Multifunctional mountain forests

While protection from natural hazards remains the main function of mountain forests, diversity of landscape and recreation are values of growing importance for an increasingly urbanised society. Timber production and creation of local employment are significantly less important. There is a high level of consensus between government forest policy and the expectations of the population, including mountain communities, that mountain forests should be multifunctional forests providing a wide range of services for different users. In trying to achieve a balance between these services, national laws can provide a useful framework, and the forest service's expert advice is necessary to deal with the complexities of multifunctionality. As mountain communities alone rarely have the financial resources needed to achieve multifunctionality, support must come from other areas that share the benefits of mountain forests.

Christian Küchli and Willi Zimmermann

Left: Owing to difficult topography, the costs of managing mountain forests sustainably are high and cannot be covered by the proceeds of timber on the market. The gap between management costs and timber prices has widened in recent decades. (WSL, Birmensdorf)

Below left: Forest protects the village of Kippel from avalanches and other natural hazards. Protection of settlements, roads and other infrastructure remains the most important role of Swiss mountain forests. (SLF, Davos)

Below right: Sub-alpine open pine forest, near Davos in the Swiss Alps. Multipurpose forests enhance the scenic beauty of a landscape. They also increase mountain biodiversity and the stability of the mountain forest ecosystem. (Swiss Federal Institute of Technology)

A call for new policies in mountain forest management

Over the last 150 years, the world has witnessed a progressive exploitation of natural resources, in quantitative as well as spatial terms. Both renewable and non-renewable resources have been consumed at increasing rates, and exploitation has extended into the most remote corners of the world. Thanks to modern technologies of mass exploitation, natural resources are now available at relatively low cost. Although this development is an important driving force behind global economic growth, it is also responsible for wasteful resource use and squandering of global environmental capital. Mountain forests have also been drawn into this highly unsustainable and even predatory mode of resource use on a global scale.

Expanding agriculture into mountain forests, Indonesia. Rather than clearing small patches, as indigenous local groups have traditionally done, immigrant settlers use slash-and-burn on a broad front. Government management of forests disrupted traditional local forms of resource use, while leaving the state unable to enforce sustainable forest management. Current forest exploitation, which is not sustainable, includes farming for subsistence as well as speculative ventures such as pepper cultivation. (Ch. Küchli)

Unsustainable levels of forest resource use: the global scene

In industrialised countries, logging carried out to obtain both timber and pulp is the main driving force behind persistently high and often unsustainable levels of forest exploitation. Logging also exerts pressure on forests in developing countries, where it is carried out for export, in order to meet demands that industrialised countries cannot meet from their own forests, as well as for domestic consumption. In addition, the growing demand for fuelwood has helped to push overall use beyond sustainable levels. Clearing land to make it available for commercial and subsistence agriculture is a further important factor leading to forest reduction and degradation in these countries.

With respect to logging, state control of forestland has been instrumental in facilitating extractive use of large sections of forestland in lowland areas and in mountains, in both industrialised and developing countries. In most places, this control has replaced traditional entitlements, thus depriving local user groups of access to forest resources.

Despite their relative remoteness, mountain forests have increasingly been the focus of modern, large-scale exploitative logging in recent decades, especially in places where road construction allows mechanised harvesting and transportation. At the same time, mountain communities are exerting increasing pressure on forests, as they face mounting difficulties in securing their livelihoods owing to population growth and lack of economic alternatives. Often the poorer segments of these societies are particularly dependent on wood, non-wood forest products, and grazing.

Biased forest policies: the dominance of downstream interests

National authorities are well aware of the important role that mountain forests play in the development of downstream areas. Mountain forests provide fresh water of good quality for urban centres, as well as water for the generation of hydropower, for industrial use, and for irrigation. These forests are also crucial in protecting main traffic routes and power lines from natural hazards; in addition, they provide recreation areas for growing urban populations. Forest policies often have a marked tendency to represent these downstream interests at the expense of upstream interests, addressing the demands of urbanised, industrialised, and consumer-oriented development, which are expressed by well-organised and power-

ful constituencies. The role of mountain forests in supporting the livelihood of mountain people is overlooked or ignored when downstream interests come into play, especially where minority groups are concerned. Moreover, forestry services have a tendency to adopt a top-down custodial attitude towards forest management, perceiving local uses as incompatible with professional forest management. This attitude, clearly a colonial legacy, excludes local communities from participation in forest management and can even lead to criminalisation of long-established local traditions of resource use in mountain forests.

Extensive clearcuts in the mountains of British Columbia, Canada. Logging for timber and pulp is the main cause of forest degradation and loss in industrialised countries. Despite its extensive forest cover, Canada has continued to cut its forests at unsustainably high rates. (M. Price)

Policy failures

It is apparent that neither the global driving forces of natural resource use nor prevailing policies and institutional attitudes are conducive to sustainable and equitable use of mountain forests. What can be done to change this situation?

A new overall framework for the use of natural resources

First, there is a need to rethink natural resource use and management at the global level. Any policy aimed at sustainable forest management needs to be embedded in an overall framework of resource policy that looks beyond the forestry sector to consider that both renewable and non-renewable natural resources are finite. This fact must be reflected in the political and institutional frameworks of national economies as well as in global economic activities – for example, through taxation of exploitation and taxation of environmental pollution. Only then will it be possible to use natural resources sustainably and put an end to their careless exploitation.

Harvesting leaf fodder for cattle in a home garden on the slopes of Kilimanjaro, Tanzania. Rural afforestation, including the promotion of home gardens and agroforests, can help reduce pressure on mountain forests. (Ch. Küchli)

Changing perceptions in mountain forest policy

Second, even if immediate action is taken to set up and implement such an overall resource policy framework, economic transformation takes time, and it will take even longer until its effects are felt. In the meantime, it will therefore be necessary to compensate local owners and users for activities that maintain the specific roles of mountain forests for the benefit of society at large. Examples cited in this report show that compensation is possible under very different socio-economic conditions (see the chapters on Costa Rica and Switzerland), and that it can be applied to a wide range of services, such as watershed conservation, conservation of biodiversity, and protection from natural hazards. Logging need not be ruled out as a form of forest use, but it must be managed in such a way (selective single-stem harvesting) that it does not threaten the protective functions of mountain forests.

Most importantly, mountain forest policy needs to be embedded in an overall concept of mountain development, within which local communities are accepted as key stakeholders. This concept must provide for restoration of local rights and entitlements to use mountain forests. Moreover, restoration of these rights must be reflected in long-term tenure regulations guaranteed by legitimate political authorities.

Global forest resources under pressure: between 1970 and 1995, the value of legal forest product exports worldwide almost tripled in constant dollars, to more than US$ 142 billion a year. And fuelwood and charcoal production increased from 1099 to 1839 million cubic meters per annum between 1965 and 1995. (Source: World Resources Institute, *The State of the World* 1999:62)

Creating opportunities for the 21st century

Joining forces to achieve multifunctionality with a focus on the protective functions of mountain forests

In order to safeguard mountain forests and assure their many important roles for the benefit of humankind in the 21st century, forest policy and management need to adopt a holistic, multifunctional approach that tries to balance the productive, protective, and cultural functions of mountain forests. It will be necessary to meet the needs and encourage the stewardship of all major stakeholders – especially local people – and integrate forest issues into broader programmes for the sustainable use of natural resources which take into account that life in many mountain areas is threatened without the protective cover of their forests. These should be the priorities of policies that aim to implement activities which foster sustainable use of mountain forests.

Mountain forests under pressure

Mountain forests have come under increasing pressure in many parts of the world in recent years – for many reasons.

In developing countries, many mountain forests are exposed to overexploitation caused by demands for wood from local communities and urban and lowland populations. Non-sustainable use of timber and the granting of excessive timber concessions – typically without the enforcement of requirements for reforestation – also play crucial roles. Forest clearing for agricultural land by local people, usually the result of the lack of other livelihood opportunities, contributes to overexploitation. These factors are heavily influenced by political and legal conditions. Economic pressures resulting from unstable prices for raw materials, worsening terms of trade, budget deficits, and increasing debt are often compensated by the overexploitation of natural resources, including mountain forests.

In developing and industrialised countries, loss of old growth forests and biodiversity is a paramount concern. In a number of industrialised countries, particularly in the European Alps, underexploitation reduces the vitality of mountain forests; this impairs their key role of protecting settlements, rail and road systems, and other infrastructure. Underexploitation is caused mainly by the substitution of fuelwood by oil and hydroelectricity, and of timber by other construction materials. As a result, the sustainable management of protective mountain forests is often not worthwhile in economic terms and must be supported by subsidies and transfer payments.

On a global scale, increased environmental stress, such as that caused by air pollution and acid rain, has already severely damaged mountain forests. Climate change may pose additional problems of adaptation and survival for mountain forests in the future.

The cumulative effects of unsustainable levels of use and environmental stress are difficult to assess – but they undermine the ability of mountain forests to fulfil the many roles they are expected to play. This has enormous consequences for people in both the mountains and the lowlands.

The challenges ahead…

…at all levels: 3 guiding principles for the protection and sustainable use of mountain forests

- Efforts aimed at implementing measures to protect mountain forests need to be based on enhanced coordination at the international and national levels, consider local specificities, and integrate forest issues into broader policies and programmes.
- The search for ways to protect mountain forests and use them sustainably needs to go beyond the sectoral perspective of professional forestry.
- Local people are central actors in forest resource use; their needs must be considered in shaping policies and implementing activities geared towards sustainable use of mountain forests.

Left: Akha village and its forest, Muang Sing District, northern Laos. Local communities are key stakeholders in all initiatives aimed at achieving a sustainable balance between use and protection of mountain forests. (T. Kohler)

Right: Tourists and students at a public excursion, Aletsch region, Switzerland. Creating awareness of the importance of mountains and their forests can help rally public support for sustainable use of mountain forests. (H.P. Liniger)

…at the local level

Measures designed to manage mountain forests sustainably will fail if they do not meet the needs of local people. However, local communities are not uniform; they often differ widely in economic, social and cultural terms, and hence in their influence and power to use local resources. Local communities therefore need to be encouraged to seek equity in the use of mountain forests. Mountain forests are a slow-growing resource, which often grows in marginal environments. It should be managed with a longer-term view; local communities are thus well advised not to accept short-term profits based on exploitative schemes offered by outside agents or firms. Local communities must also be encouraged to revitalise or establish local institutions with the authority to enforce regulations for the sustainable and equitable use of their forests, and to mitigate local conflicts that might arise regarding their use.

…at the national level

There is a need for national forest policies that adopt a long-term view within an overall framework of the sustainable use of natural resources. Such policies will consider the site-specific characteristics of mountain forests and the needs of local mountain communities with regard to mountain forest use. Typically, mountain forests fulfil many different roles for mountain communities as well as for many other users such as industry, tourism, transportation, and urban populations. Highland-lowland interests as well as rural-urban needs must be carefully balanced. Multifunctionality – with a focus on the protective functions that are a specificity of mountain forests – can be a useful concept to achieve this aim.

There is a need for the political will to implement policies and legislation according to the principles of subsidiarity and decentralisation. Fostering local stewardship and accountability for mountain forest management on the basis of secure land tenure and local user rights is an important element of these principles. Alternative sources of energy such as solar power and hydropower can reduce the demand for fuelwood; ways must be found to support such alternatives. Finally, appropriate government policies can help provide an enabling environment for potential investors willing to create employment opportunities in the industrial and service sectors. This will be important in reducing pressure on natural resources, including mountain forests.

Where protective rather than productive uses need to be prioritised for reasons of national or international interest – such as protection of watersheds or conservation of biodiversity – the benefits must accrue to the user groups which forsake use, in order to compensate them for loss of opportunities of use and for managing forests for the benefit of the society at large.

…at the international level

Numerous international initiatives and programmes have been launched within the forestry sector in recent years, such as the Centre for International Forestry Research (CIFOR), the Intergovernmental Panel on Forests and the Intergovernmental Forum on Forests (IPF/IFF). These need to be coordinated. Moreover, the efforts made by these initiatives and programmes must take account of mountain forests and the interests of the stakeholders who depend on them.

In any effort on behalf of mountain forests, it is important to consider issues addressed in other chapters of Agenda 21, including those indirectly concerned with mountain resources. These include international efforts to reduce debt, efforts to expand market access for developing countries, implementation of international conventions – such as those on climate change and biodiversity – and financial mechanisms such as the Global Environment Facility (GEF).

Regional cooperation and networking with regard to the sustainable use of forest resources need to be encouraged, including, for example, policies regarding timber extraction (concessions), watershed management, and other transboundary issues such as biodiversity conservation.

Logs waiting to be processed in the Comunita Magnifica di Fiemme, Italy. The forests in this valley are the first in the Alps to be certified by the Forest Stewardship Council, which guarantees that all the wood is produced sustainably. (M. Price)

…for civil society and NGOs

These institutions have important roles to play in creating awareness, lobbying governments and key commercial users – such as the timber and tourism industries – and in genuine cooperation with all concerned partners. Equally important, they can demonstrate their commitment and effectiveness in designing, implementing, and providing support for locally appropriate, innovative combinations of mountain forest conservation and use. They can help forge local users' unions and provide support for minorities and for women, who depend most on forest resources in many mountain regions but who lack the support they need to express and safeguard their own interests. Civil society and NGOs can also help increase political acceptance of sustainable resource use at regional, national and international levels.

…for the timber industry and other commercial users

The timber industry and other commercial users such as the tourism industry have key roles to play in developing techniques of sustainable use, based on the principles of multifunctionality, and in compensating local communities for their stewardship. While basic economic principles and shareholder value will remain important aspects of logging and other commercial operations, the timber industry could do more to support product labels and give higher priority to certificates of sustainable forest management. It has a responsibility to help forge active partnerships with other stakeholders, especially mountain communities. To achieve long-term sustainability, the timber industry and other commercial users should be invited to consider innovative ways to finance complementary efforts that avoid or mitigate adverse environmental and social impacts that result from their activities, to develop an internationally binding code of conduct for the sustainable use of mountain forests, and to train their staffs to make their operations more sustainable.

…for the scientific and research communities

There is need to gain better understanding of mountain forests. First of all, this applies to forest ecology and silviculture. The main characteristics of many plant and animal species and their functions in forest ecosystems are still largely unknown, especially in tropical mountains. Likewise, understanding of the impacts of environmental stress, including air pollution and the effects of climate change, will require research based on long-term strategies. Second, research should be targeted to the economic and socio-cultural aspects of forest resource use, including economic and societal valuation of mountain forests and the effects of different land use systems on watersheds. Third, greater understanding is needed of the many locally developed land-use systems, especially those linking agriculture with forest resources (shifting cultivation, agroforestry). These systems provide valuable experience both in the local context and further afield.

In their efforts to develop alternatives for the sustainable use of mountain forests, researchers should join forces with important stakeholder groups such as local users, the timber industry, other commercial users including the tourism industry, and forest authorities. Scientists must use their knowledge to educate and train forestry staff and practitioners about the multiple functions of mountain forests and the diverse groups that depend on them. Finally, they must more effectively communicate their key findings to policy-makers, donors, and the general public – especially young people – in order to ensure informed decision-making and public support for the sustainable use of mountain forests.

Towards 2002 – and beyond

The year 2002 will be the International Year of Mountains (IYM). 2002 thus presents an excellent opportunity for collaboration among all stakeholders interested in sustainable development of mountain forests, to ensure that these forests are managed more sustainably than they often have been in the past. There is a need to balance the many productive, protective, and cultural functions and values of mountain forests. Acknowledging the protective role of mountain forests – their most important function in many mountain regions – for sustainable use of watersheds, protection from natural hazards, and conservation of biodiversity, could be a first step towards achieving such a balance, and towards a common understanding of the need for sustainable use of mountain forests.

References on forests in mountain development

Information on selected further references (books, journals, CD-ROMs) can be obtained from the Mountain Agenda: agenda@giub.unibe.ch, or from the Mountain Forum: mfmod@mtnforum.org

Mountains of the World
Mountain Forests and Sustainable Development

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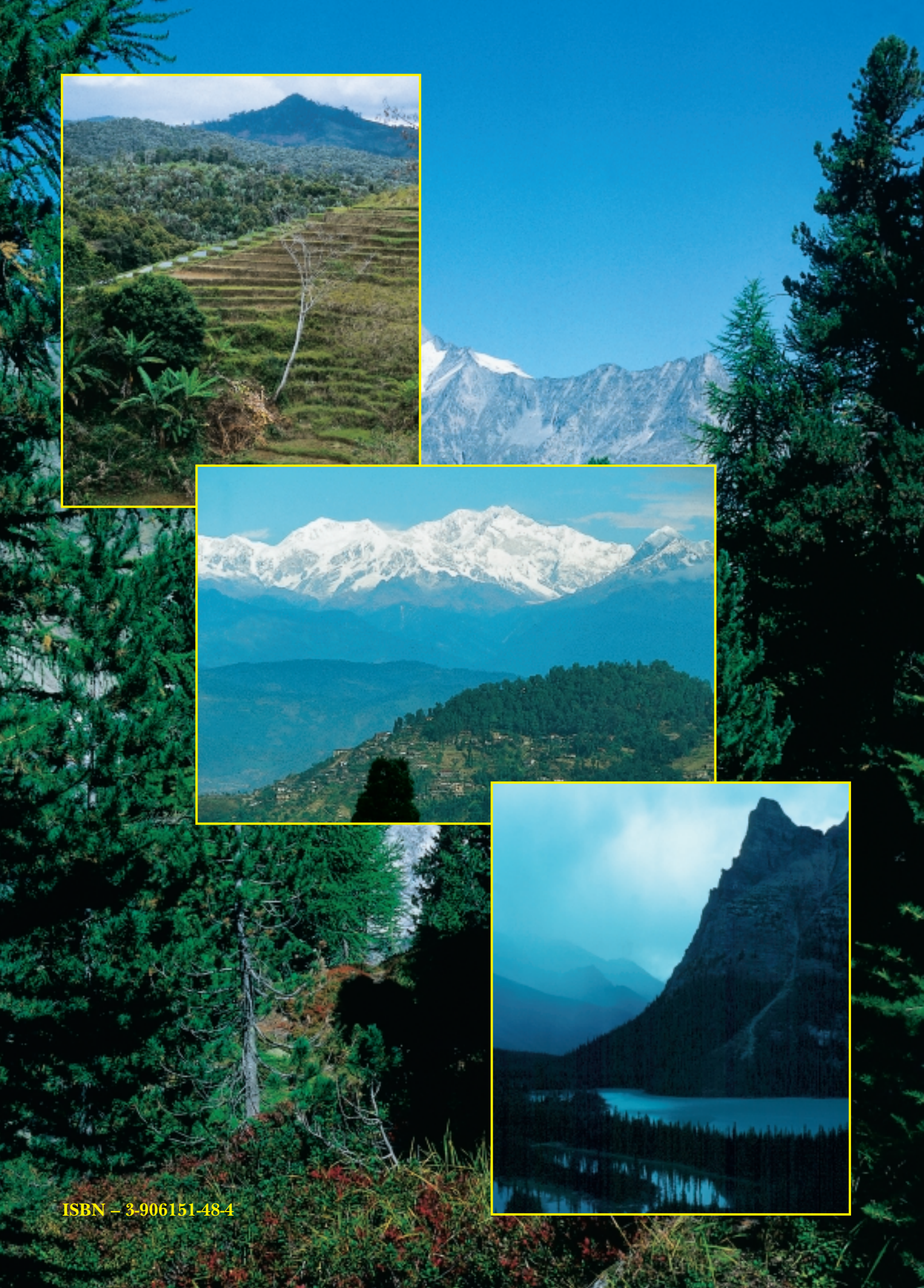
FAO	Food and Agriculture Organization of the United Nations, Rome
ICIMOD	International Centre for Integrated Mountain Development, Kathmandu
IGU	International Geographical Union
TMI	The Mountain Institute, Franklin (USA)
UNESCO	United Nations Educational, Scientific and Cultural Organization, Paris
UNU	United Nations University, Tokyo

Front cover:
Mountain forest in the Aletsch Region, Switzerland (H.P. Liniger)

Back cover: (from above):
Mountain forest landscape in eastern Madagascar (P. Messerli); Darjeeling with Kanchanjunga in the background, India (U. Lutz); Lake O'Hara area, British Columbia, Canada (M. Price)



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