UNEP, Zhan Huang, China, Still Pictures

Land

Global overview

The land area of the Earth covers a total of more than 140 million km^2 — somewhat less than one-third of the Earth's surface. Land resources are finite, fragile and non-renewable. They include soil, which is mainly important for agriculture; land cover, which is important for the environment; and landscapes which are an important component of human habitat and welfare. Besides forming a basis for plant and animal life support systems and agricultural production, land aids in the preservation of terrestrial biodiversity, regulation of the hydrological cycle, carbon storage and recycling, and other ecosystem services. It acts as a store of raw materials, a waste dump and landfill for both solid and liquid waste, and a basis for human settlement and transport activities (FAO 1995a, Wood, Sebastian and Scherr 2000).

The 1992 Earth Summit took a step forward in bringing problems associated with land resources to wider attention. In *Agenda 21* (UNCED 1992), Chapters 10, 12, 13 and 14 relate to land, covering the integrated approach to management of land resources, desertification and drought, mountain region development and sustainable agriculture. In the discussions of deforestation, biological diversity and freshwater resources (Chapters 11, 15 and 18), significant emphasis is placed on land as a productive resource, the importance of sustainable land use, and environmental pollution and conservation. *Agenda 21* has remained a primary basis for land resources policy although a further landmark of awareness of land at the highest policy level is found in the review prepared for the UN Millennium Summit (UN 2000). This review identifies the threats to future global food security arising from problems of land resources.

Agriculture and food production

Since 1972, the main driving force leading to pressure on land resources has been increasing food production. In 2002, food is needed for some 2 220 million more people than in 1972 (United Nations Population Division 2001). The trend during the decade 1985–95 showed population growth racing ahead of food production in many parts of the world, particularly Africa: in 64 of 105 developing countries studied in this period, food production lagged behind population growth (UNFPA 2001).

Agricultural land (defined as land under arable use plus permanent crops) has increased steadily in developing regions but not in developed ones (see graph). The decrease in developed regions seems to have been driven less by availability of land resources than by economic forces, including overproduction of major commodities and decreasing prices for farm produce.

Policy failure and poor agricultural practices contribute to increased land pressure. For example, the excessive use of fertilizers and other chemicals contributes to soil degradation and water pollution. Between 1972 and 1988, global fertilizer use grew at an annual average of 3.5 per cent or by more than 4 million tonnes a year (FAO 2001). Up to the 1980s, maintenance and improvement of fertility was thought of chiefly in terms of addition of mineral fertilizers, and agricultural subsidies increased the use of fertilizers further. Government policies supported farmers by subsidizing agricultural inputs such as irrigation, fertilizer and pesticides. A study by FAO of 38 developing countries showed that 26 of them subsidized fertilizer use (FAO/IFA 1999).

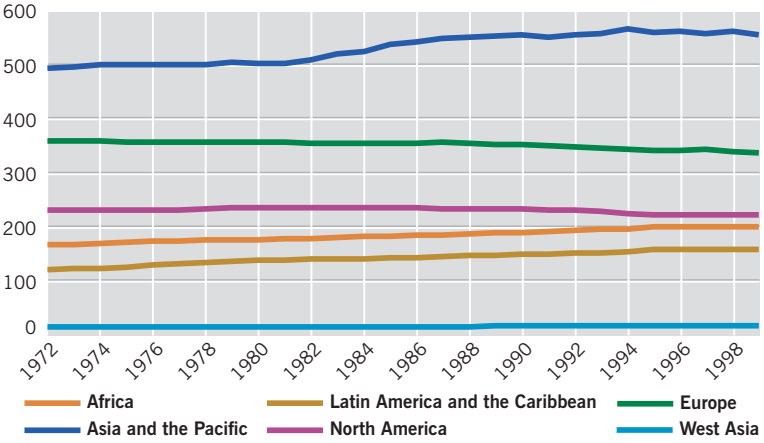
Pesticides continue to be used indiscriminately (sometimes illegally) in places, and disposed of casually. A survey published by FAO of countries in Africa and the Near East reported stocks of unwanted or banned pesticides amounting to more than 16 500 tonnes at some 1 000 sites in 49 countries (FAO 1995a).

Irrigation has also made, and continues to make, an important contribution to agricultural production but the potential for future growth has changed. The efficiency of many irrigation schemes is low and land degradation problems are widespread. Poorly designed and implemented irrigation schemes can cause waterlogging, salinization and alkalization of soils. Some 25–30 million ha of the world's 255 million ha of irrigated land were severely degraded due to the accumulation of salts, according to 1995 FAO estimates. An additional 80 million ha were reported to be affected by salinization and waterlogging (FAO 1995b). In the 1980s it was estimated that about 10 million ha of irrigated land were being abandoned annually (WCED 1987) although the total irrigated area has continued to rise (see graph).

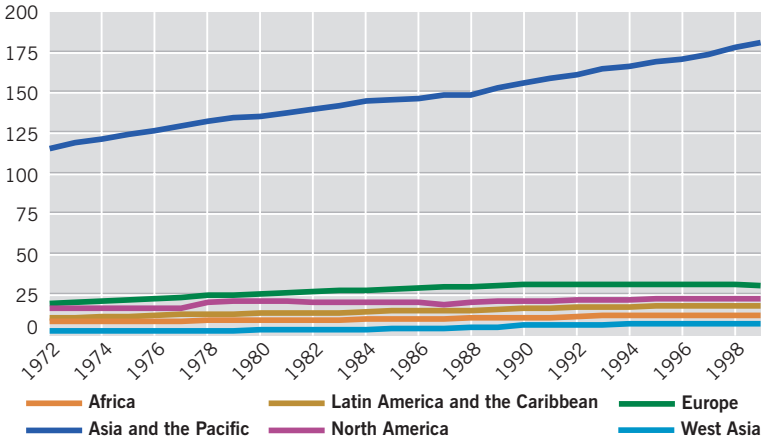
Land degradation

Land degradation leads to a significant reduction of the productive capacity of land. Human activities

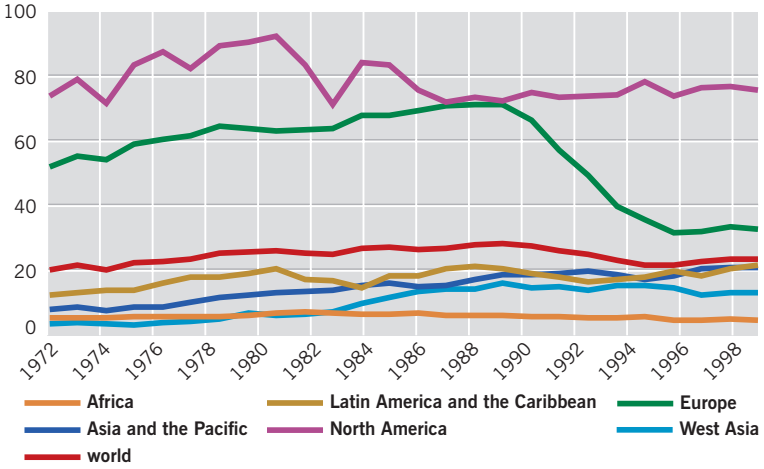
Area under arable and permanent crops (million ha)



Area under irrigation (million ha)



Fertilizer consumption (kg per capita/year)



Graphs above show 30-year trends in three major agricultural variables: agricultural area, irrigated area and per capita fertilizer consumption. Fertilizer consumption has fallen in Europe and North America but continues to climb — albeit slowly — elsewhere

Source: compiled from FAOSTAT 2001 and United Nations Population Division 2001

Extent and causes of land degradation

Degradation extent	*Cause*
580 million ha	**Deforestation** — vast reserves of forests have been degraded by large-scale logging and clearance for farm and urban use. More than 220 million ha of tropical forests were destroyed during 1975–90, mainly for food production.
680 million ha	**Overgrazing** — about 20 per cent of the world's pasture and rangelands have been damaged. Recent losses have been most severe in Africa and Asia.
137 million ha	**Fuelwood consumption** — about 1 730 million m^3 of fuelwood are harvested annually from forests and plantations. Woodfuel is the primary source of energy in many developing regions.
550 million ha	**Agricultural mismanagement** — water erosion causes soil losses estimated at 25 000 million tonnes annually. Soil salinization and waterlogging affect about 40 million ha of land globally.
19.5 million ha	**Industry and urbanization** — urban growth, road construction, mining and industry are major factors in land degradation in different regions. Valuable agricultural land is often lost.

Source: FAO 1996

contributing to land degradation include unsuitable agricultural land use, poor soil and water management practices, deforestation, removal of natural vegetation, frequent use of heavy machinery, overgrazing, improper crop rotation and poor irrigation practices. Natural disasters, including droughts, floods and landslides, also contribute. A Global Assessment of Soil Degradation (GLASOD) was undertaken in the early 1990s (Oldeman, Hakkeling and Sombroek 1990, UNEP 1992) and a land degradation assessment of drylands (LADA) was initiated by GEF and UNEP in 2000 and is now being developed with FAO.

It has been estimated that 23 per cent of all usable land (excluding mountains and deserts, for example) has been affected by degradation to a degree sufficient to reduce its productivity (UNEP 1992, Oldeman, Hakkeling and Sombroek 1990). In the early 1990s, about 910 million ha of land were classified as 'moderately degraded', with greatly reduced agricultural productivity (see illustrations opposite). A total of 305 million ha of soils ranged between 'strongly degraded' (296 million ha) and 'extremely degraded' (9 million ha, of which more than 5 million ha were in Africa). 'Extremely degraded' soils are beyond restoration (Oldeman, Hakkeling and Sombroek 1990).

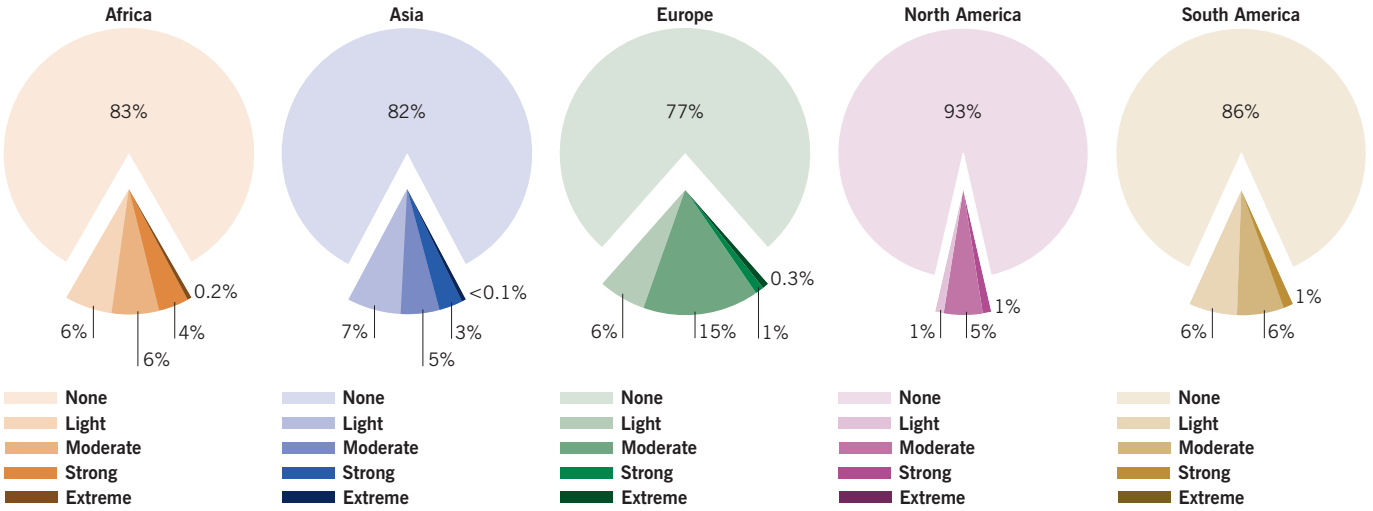
Despite these compelling statistics on land degradation, some studies are beginning to question the data, arguing that degradation estimates are overstated. A major reason suggested for the overestimation of land degradation has been underestimation of the abilities of local farmers (Mazzucato and Niemeijer 2001). These authors argue that ' … experts need to discriminate more carefully between a naturally bad state, a temporary bad state and a degraded state of land'.

Soil erosion is a major factor in land degradation and has severe effects on soil functions — such as the soil's ability to act as a buffer and filter for pollutants, its role in the hydrological and nitrogen cycle, and its ability to provide habitat and support biodiversity. About 2 000 million ha of soil, equivalent to 15 per cent of the Earth's land area (an area larger than the United States and Mexico combined), have been degraded through human activities. The main types of soil degradation are water erosion (56 per cent), wind erosion (28 per cent), chemical degradation (12 per cent) and physical degradation (4 per cent). Causes of soil degradation include overgrazing (35 per cent), deforestation (30 per cent), agricultural activities (27 per cent), overexploitation of vegetation (7 per cent) and industrial activities (1 per cent) (GACGC 1994).

Approaches to soil conservation have been greatly modified since the 1970s. Work used to concentrate on mechanical protection, such as bunds and terraces, largely to control surface run-off. This has been supplemented by a new approach (Shaxson and others 1989, Sanders and others 1999) which calls for greater attention to biological methods of conservation, and the integration of water conservation with soil protection, through improved management of soil-plant-water relationships, including reduced disturbance by tillage (University of Bern and others 2000). Within the international agricultural research system, the Consultative Group on International Agricultural Research, there is now a commitment to natural resource management, and explicit recognition of degraded land and desertification as environmental problems (Shah and Strong 1999).

Despite these developments, there is no clear indication that the rate of land degradation has decreased. As yet, there are no continuously monitored indicators of soil condition that would

Extent and severity of land degradation

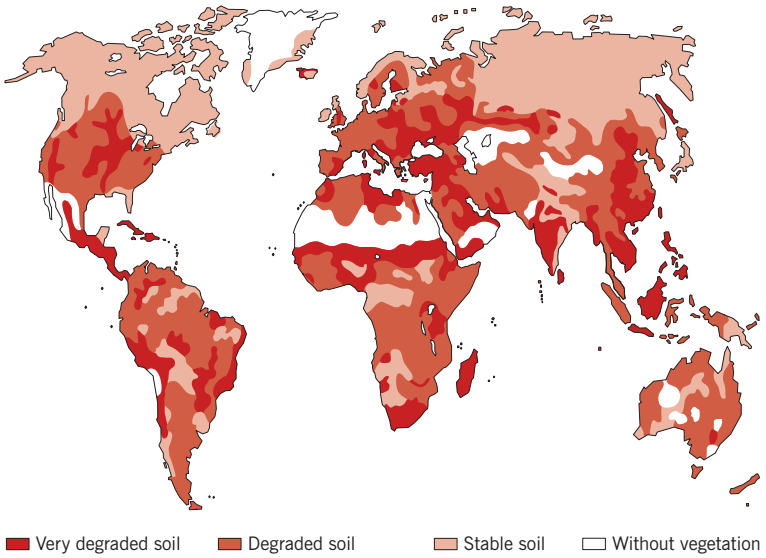


permit quantitatively based assessments of changes over time, comparable to the monitoring of deforestation.

It has been suggested that soil monitoring should become a basic task of national soil survey organizations (Young 1991) but this proposal has yet to be widely adopted. An international programme was set up to develop a set of land quality indicators (Pieri and others 1995), comparable to those used to monitor economic and social conditions. The programme continues on a modest scale under the Global Terrestrial Observation System.

Desertification

The UN Convention to Combat Desertification (UNCCD) defines desertification as 'land degradation in arid, semi-arid and dry sub-humid areas' brought about by factors such as climatic variations and human activities. Around 3 600 million ha, or 70 per cent, of the world's drylands (excluding hyper-arid deserts) are degraded (UNCCD 2000a). Many parties to the convention have now prepared national action programmes to strengthen activities to combat desertification and drought (UNCCD 2000b, 2001). However, there is no indication that governments are developing structures through which bottom-up action programmes could be implemented at the local level (CSE 1999). In addition, inadequate resource mobilization is hampering the affected developing countries' efforts to fulfil their commitments under the convention. A recent analysis of the CCD (Toulmin 2001) argues that the convention model was ill-advised as 'it has tied people into a series of COP [Conference of the Parties] performances which demonstrate no linkage with real problems on the ground'. The desertification problem remains poorly understood as the available data show: estimates of areas affected range from one-third of the world's surface area to about 50 per cent, and people affected from 1 in 6 to 1 in 3 (Toulmin 2001).



Pie charts and map above show the extent of areas of degraded land in the world and the location of degraded soils

Note: regions do not correspond exactly with GEO regions

Source: UNEP 1992 and GRID Arendal 2001

Climate change

The consequences of global climate change on agriculture and ecosystems are highly uncertain. Based on simulation models, the most likely impacts

Climate change impacts on land and biodiversity by region

Region	*Adaptive capacity, vulnerability and key concerns*
Africa	Grain yields are projected to decrease for many scenarios, diminishing food security, particularly in small food-importing countries.
	Desertification would be exacerbated by reductions in average annual rainfall, run-off and soil moisture, especially in Southern, Northern and Western Africa.
	Significant extinctions of plant and animal species are projected and would affect rural livelihoods, tourism and genetic resources.
Asia and the Pacific	Decreases in agricultural productivity and aquaculture due to thermal and water stress, sea-level rise, floods and droughts, and tropical cyclones would diminish food security in many countries of arid, tropical and temperate Asia; agriculture would expand and productivity would increase in northern areas.
	Climate change would exacerbate threats to biodiversity due to land-use and land-cover change and population pressure in Asia.
	In Australia and New Zealand, the net impact on some temperate crops of climate and CO_2 changes may initially be beneficial but this balance is expected to become negative for some areas and crops with further climate change.
	Some species with restricted climatic niches and which are unable to migrate due to fragmentation of the landscape, soil differences or topography could become endangered or extinct.
Europe	There will be some positive effects on agriculture in northern Europe; productivity will decrease in southern and eastern Europe.
Latin America	Yields of important crops are projected to decrease in many locations in Latin America, even when the effects of CO_2 are taken into account; subsistence farming in some regions of Latin America could be threatened.
	The rate of biodiversity loss would increase.
North America	Some crops would benefit from modest warming accompanied by increasing CO_2 but effects would vary among crops and regions, including declines due to drought in some areas of Canada's Prairies and the US Great Plains, potential increased food production in areas of Canada north of current production areas and increased warm-temperate mixed forest production.
Polar	Natural systems in the polar regions are highly vulnerable to climate change and current ecosystems have low adaptive capacity; technologically developed communities are likely to adapt readily to climate change but some indigenous communities, in which traditional lifestyles are followed, have little capacity and few options for adaptation.
Small Island States	The projected sea-level rise of 5 mm/year for 100 years would cause enhanced coastal erosion, loss of land and property, dislocation of people.
	Limited arable land and soil salinization makes agriculture of small island states, both for domestic food production and cash crop exports highly vulnerable to climate change.

Source: IPCC 2001

Population controversy

'Many people identify growing population pressures of the poor and the resultant overgrazing, deforestation and unsustainable agricultural practices as major causes of desertification. This theory, however, is based on the assumption that only the poor and their growing populations cause environmental degradation. It misses the impact of a chain of international trade and economic practices which result in low prices for agricultural and livestock commodities for the South; and political compulsions such as debt, which force a country to promote adverse land use practices in order to earn foreign exchange. In its simplistic reaction, the West chooses to provide food, first through aid and then by promoting increased agricultural production. The problem still persists, showing that the solution is far more complex.'

Source: CSE 1999

are net favourable effects for the cooler margins of the temperate zone, and adverse consequences for the sub-tropical semi-arid zone (see box). Regional changes in climate have already affected diverse physical and biological systems in many parts of the world. Mid- to high-latitude growing seasons have lengthened. Poleward and altitudinal shifts of plant and animal ranges have been observed (IPCC 2001). Natural systems at risk of climate change include glaciers, atolls, polar and alpine ecosystems, prairie wetlands and remnant native grasslands. Human systems that are vulnerable include agriculture, particularly food security, and forestry.

From the 1990s, the climate change issue directed attention to the role of land as a terrestrial store of carbon. Land degradation almost always involves a loss of soil organic matter. If this trend can be checked or reversed, a considerable potential exists for carbon sequestration through building up the levels of carbon stored in soils and the vegetation cover (IFAD/FAO 1999).

Human settlements and infrastructure

Urban areas occupy only 1 per cent of the Earth's land area (UNEP 2000). However, urban expansion, including land requirements for industry, transport and for leisure activities in all regions, increases pressures on land resources. In the United States, for example, about 400 000 ha of farmland are lost to urbanization annually and China lost about 5 million ha of farmland

to towns and cities during 1987–92 (UNFPA 2001). Land degradation, river siltation and soil pollution, from acid rain and industrial wastes, are some of the environmental issues associated with urbanization and industrialization.

The waste generated by cities is a major source of degradation. It is estimated that about 1.95 million ha of land have been degraded by industry and urbanization (FAO 1996). One cause has been the export by some developed countries of hazardous and toxic wastes to developing regions.

The international response to this was the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. The Basel Convention, which entered into force in 1992 (see Chapter 1), aims to reduce transboundary movements of hazardous wastes, minimize the creation of such wastes, and prohibit their shipment to countries lacking the capacity to dispose of hazardous wastes in an environmentally sound manner.

Urbanization has also spawned urban agriculture (see 'Urban areas'), which was hardly recognized internationally in the 1970s but has been expanding globally over the past 15-20 years, 'more rapidly than urban populations, and in many countries more rapidly than their economies' (Smit 1996). Urban agriculture takes place on both public and private land, both legally and illegally. More than 800 million urban dwellers were involved in urban agriculture in 1993 (Smit 1996). For example, in the Brazilian city of São Paulo, agriculture is a major planned land use in the city's metropolitan master plan, which was adopted in the 1990s.

In virtually all regions, urban agriculture has become one of the major food-producing activities. For example, most households in the Southeast Asia and Pacific Island sub-regions practise urban agriculture (Sommers and Smit 1994). About 30 per cent of the Russian Federation's food is produced on 3 per cent of the land in suburban dachas (Sommers and Smit 1994). In Moscow, families engaged in agriculture grew from 20 per cent of the city's population in 1970 to 65 per cent in 1990 (Smit 1996). During 1980–90, urban agriculture in the United States grew by 17 per cent (Smit 1996). In some African urban areas, the response by municipal authorities has been to cut down the crops to enforce land-use by-laws.

The impacts of urban agriculture include air, water and soil pollution, mainly from improper use of chemicals. Advocates of urban agriculture argue that, in addition to providing food, the activity can contribute to improving the environment through recycling organic matter. Solid wastes can be composted and used to fertilize soils.

Much good agricultural land is threatened by chemical pollution, particularly — as here in China — by waste products from urban centres. Chemical degradation is responsible for 12 per cent of global soil degradation

Source: UNEP, Zehng Zhong Su, China, Still Pictures

Chemicals and land use

Important recent developments include:

- The Stockholm Convention on Persistent Organic Pollutants (POPs) was adopted in May 2001 (see Chapter 1).
- UNEP, together with FAO and WHO, is promoting more sustainable practices in replacing POP pesticides with integrated pest management. The Global Crop Protection Federation is playing a proactive role in promoting the judicious use of pesticides and the prevention of toxic exposures and misuse of pesticides.

Other actions include pilot projects to demonstrate the technical and economic feasibility of new technologies to destroy obsolete chemicals and pesticides; and the encouragement of donors and industry to increase funding for management and disposal of these substances.

Urban agriculture in Zimbabwe

In Harare, Zimbabwe, sanctions on urban agriculture were lifted temporarily in 1992. Within two years, the area cultivated had doubled and the number of farmers more than doubled. Municipal costs for landscape maintenance and waste management were down, food prices were down, and hundreds of jobs had been created. Several benefits were gained from just a change in policy. Similar policy-related benefits were documented in Lusaka and Accra in the 1970s (Smit 1996).

Conclusion

The increase in world population means that pressures on land will continue to be acute, particularly in Africa and Asia. The increased needs for food and other agricultural products must be met mainly by raising and sustaining crop and livestock yields and by more intensive land use. This has to be accompanied by more efficient harvesting and processing of products so as to reduce post-production losses. However, current projections also assume an expansion of the arable area in developing countries, although at half the rate of the previous 30 years (FAO 2001). By 2030, FAO estimates suggest that an additional 57 million ha will be brought into cultivation in Africa, and 41 million ha in Latin America, increases of 25 per cent and 20 per cent respectively (FAO 2001). This expansion must necessarily come either from further conversion of forest and woodland, or by bringing into cultivation fragile areas of the semi-arid zone, both of which raise serious environmental concerns.

Meeting these challenges will stretch the limited resources currently allocated to agricultural research and development, and may call for reallocation of the scarce funding available. It will, in addition, require good governance, land and soil policies, and continued

Land and the International Year of Mountains: importance of the mountain commons

Litter on a mountainside in China

Source: UNEP, Zhe Hao, Still Pictures

Mountains can provide crucial resources for social and economic development. Mountain commons provide essential local and downstream environmental products and services such as freshwater supplies, irrigation, hydropower, flood control, biodiversity conservation and tourism. However, with few exceptions, mountain commons are ecologically under-managed and suffer from the classic 'commons syndrome': while all seek to benefit, stakeholders lack coordination, incentives and instruments for joint care.

Satellite imagery shows significant loss of mountain forests and other vegetative cover over the past 20 years. The causes are often inappropriate agriculture and livestock developments in fragile areas. Downstream, poor watershed management causes siltation of rivers and reservoirs, and allows natural disasters to take an unprecedented toll as roads, bridges and sometimes entire communities are washed away.

Whenever mountain ecosystems are degraded by overexploitation, costs to businesses and communities are high. As vegetation is removed, aquifers and wells run drier. Siltation reduces the sustainability of hydropower and irrigation reservoirs. Agricultural run-off spoils the purity of renewable sources of freshwater. Fisheries suffer and urban water supplies dwindle in the dry season. In deforested mountain ranges, floods may become uncontrollable after heavy rain. They cause global damage of tens of billions of dollars every year.

Businesses stand to benefit from joining hands, and from shaping common action programmes to safeguard mountain ecosystems. This is a long-term challenge, and will require a measure of social responsibility and commitment beyond customary business horizons. Local, long-term, strategic private-public partnerships could begin to address and reverse patterns of degradation. In the same way that water-user associations are necessary in downstream water and irrigation management, there is a need for mountain-stakeholder associations. Region-by-region, these would need to equip themselves with supporting institutional, legal, economic and monitoring instruments.

The International Year of Mountains 2002 (IYM) could inspire such processes: it can draw attention to issues and opportunities; it can help network stakeholders across sectoral and company boundaries, it can promote conducive policy and incentive instruments. The business community could now build on recent work under the global water partnership agenda. The Water and Mountain Commons agenda, developed jointly by the Earth3000 NGO and UNEP's Mountain Programme, could become a tangible contribution to IYM. During the Bishkek Global Mountain Summit, the main concluding event of IYM, a special Mountain Marketplace facility will be established to promote private-public partnerships and mountain stakeholders' associations, involving upstream and downstream communities.

efforts to achieve sustainable use of land resources. A prerequisite is the adequate support by governments for national land resource institutions, and for building up the capacities of land resource planners, farmers and managers at local and national levels. Maintenance or improvement of the productive potential of land resources to meet the needs of present and future populations, while at the same time sustaining the vital ecosystem functions and other multiple uses of land, is a fundamental requirement for sustainability.

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Land: Africa

Africa's total land area covers 29.6 million km^2, of which two-thirds is arid or semi-arid (UNEP 1999a). Land is central to development in Africa since the livelihoods of about 60 per cent of the population are dependent on agriculture (Moyo 2000).

The main issues related to land in Africa include increasing degradation and desertification, together with inappropriate and inequitable land tenure systems, which have played a major role in exacerbating degradation. Other widespread problems include a decline in soil fertility, soil contamination, land management and conservation, gender imbalances in land tenure, and conversion of natural habitat to agricultural or urban uses.

Agriculture

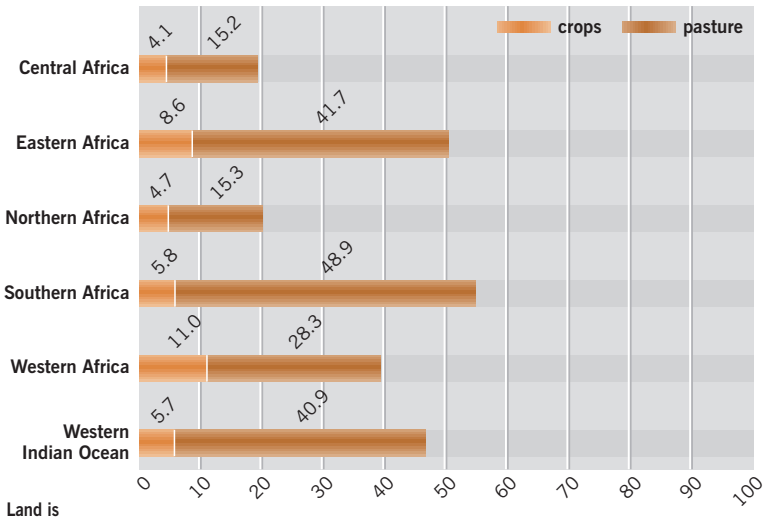
As well as providing subsistence crops for a large proportion of Africa's population, there are increasing demands on the land to produce cash crops for export, facilitating economic growth. These demands are often in conflict, and make coherent policy development and implementation a complex and difficult task. Over the past 30 years, more and more land has been converted to agriculture, most noticeably during the 1980s in response to rising commodity prices. By 1999, about 202 million ha of land in Africa were under cultivation (32 per cent of the potentially cultivable area), and 906 million ha were being used as permanent pasture (compiled from FAOSTAT 2001). The percentage of agricultural land (cultivated and pasture) varies considerably across Africa, from 54.7 per cent in Southern Africa and 46.6 per cent in the Western Indian Ocean islands to 20 per cent in Northern Africa and 19.3 per cent in Central Africa (see bar chart). The extent to which African economies are dependent on agriculture is reflected in the contribution to GNP (approximately 17 per cent during the 1990s), and to employment — more than 60 per cent of the total labour force in 1996, although this had declined from 70 per cent in 1980 (ADB 2001).

Production has increased considerably over the past 30 years, mostly due to expansion of the area under cultivation, although improvements in cultivation methods and increased use of agro-chemicals have also played a role. Cereal production in Africa was 58 million tonnes in 1975, and this had almost doubled to 106 million tonnes by 1999 (FAOSTAT 2001). Despite this, nutritional intake is still low in many parts of Africa and the number of undernourished people has doubled since 1970 (FAO 2000). The region is a net importer of cereal crops, and the ratio of imports to exports is escalating. In 2000 alone, millions of people in at least 16 African countries experienced food shortages, either due to crop failures or distribution breakdowns associated with civil conflict (FAO 2000). The lack of agricultural technologies suitable for African conditions has also contributed to under-realization of production potential (FAO 2000). Dependence on rain-fed agriculture, now that the potential for the expansion of irrigated agriculture has become limited due to water scarcity, increases the risk of food and economic insecurity, especially in areas of high climate variability. Restricted access to foreign markets, heavy agricultural subsidies in OECD countries, and limited processing before export add to Africa's vulnerability to international price fluctuations, and therefore failure to realize the full potential of its land resources.

Land degradation

The expansion of agriculture over the past three decades involved the cultivation of marginal areas, or clearance of important natural habitats such as forests and wetlands. Such conversion is a major driving force behind land degradation. In the Western Indian Ocean islands, for example, competition for land is so intense that coastal wetlands have deliberately been destroyed,

Land utilization (percentage of total land area): Africa



Land is intensively used in most African sub-regions, with more than 50 per cent of all land in use in two sub-regions

Source: compiled from FAOSTAT 2001

and inland swamps have been drained and used as construction sites (UNEP 1999b). Many African rural communities survive by moving their cattle and crops as subsiding floodwaters expose enriched bottomlands and floodplains. More than 1.5 million people in Mali, Mauritania, Senegal and Sudan depend on this resource, as do vast numbers of wild herbivores (Maltby 1986). Draining wetlands for agriculture therefore threatens not only habitats and biodiversity but also the livelihoods of pastoralists and wildlife.

Loss of natural habitats has reduced vegetation cover and exposed soils to wind and water erosion. Wind and water erosion is extensive in many parts of Africa with about 25 per cent of the land prone to water erosion and about 22 per cent to wind erosion (Reich and others 2001).

Soil erosion also causes increased rates of siltation of dams and rivers, and increased risk of flooding in rivers and estuaries. In Sudan, for example, the total capacity of the Roseires reservoir — which generates 80 per cent of the country's electricity — has fallen by 40 per cent in 30 years due to siltation of the Blue Nile (Conway 2001).

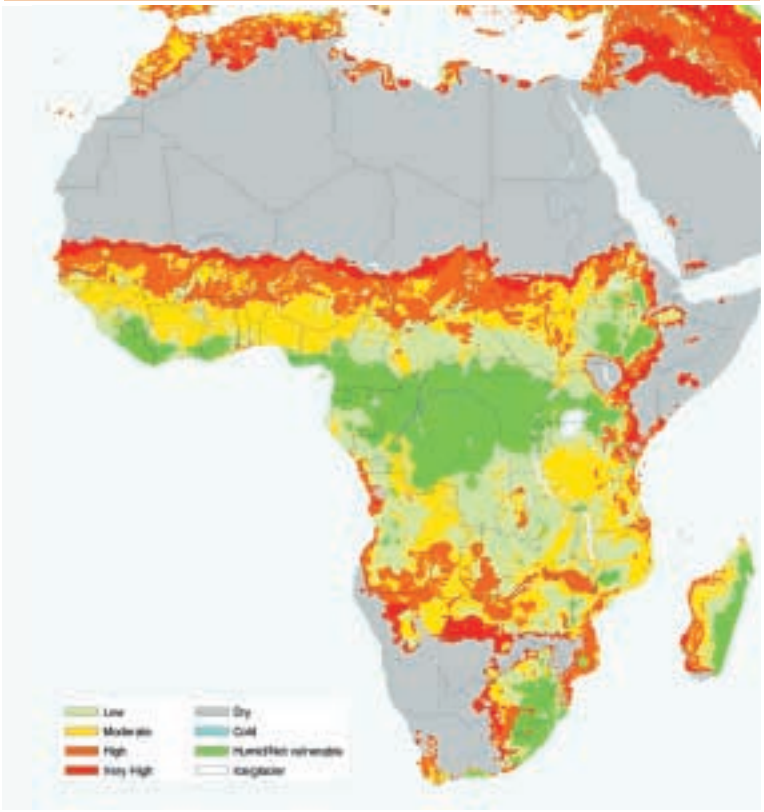
Soil erosion reduces the productivity of land, requiring farmers to apply more and more fertilizers and other chemicals that help check falling productivity. However, many small-scale farmers cannot afford to buy these inputs and so get low yields.

As a result of the increasing recognition of soil nutrient depletion, a soil fertility initiative for sub-Saharan Africa (where the problem is particularly widespread) was established in 1996 (New Agriculturalist 2001). The objective is to strengthen action by the participating agencies to improve productivity and increase farm incomes through a combination of policy reform and technology adaptation. National soil fertility action plans are currently being prepared in 23 sub-Saharan countries. Organic farming systems offer considerable scope for addressing soil fertility problems as well as raising farm incomes.

Policies on land management have generally failed to address the root causes of land degradation which stem from colonial imbalances in land distribution, lack of incentives for conservation, insecure tenure and the failure to provide for diversified rural production systems (Moyo 1998). The United Nations Convention to Combat Desertification (UNCCD) points out that land degradation is intricately linked to poverty and that addressing this problem requires the participation of the resource users and, where appropriate, providing them with alternative livelihood options. Many African nations have signed and ratified the convention, and 15 countries submitted national action programmes in 2000. The Maghreb Arab Union, Southern African Development Community, the Economic Community of West African States and the Permanent Interstate Committee for Drought Control in the Sahel also submitted sub-regional plans. This has served to raise public awareness about issues of environment and resource sustainability, but the resources required to enforce these plans have frequently been inadequate (UNCCD 2001). A recent study estimated that desertification processes affect 46 per cent of Africa, and 55 per cent of that area is at high or very high risk. The worst affected areas are along desert margins (see map), and in total about 485 million people are affected (Reich and others 2001).

The success of land conservation programmes depends on several factors, and is closely linked with socio-economic conditions. Improving the distribution

Desertification vulnerability: Africa



Desertification vulnerability map of Africa locates the 46 per cent of the area at risk, of which 55 per cent is at high or very high risk

Source: Reich and others 2001

of wealth, access to resources and economic opportunities are key factors (SARIPS 2000). Peace and political stability are vital to improving resource and food security, as shown by the low per capita food production of countries where there is conflict, and resource security is necessary to implement and sustain conservation programmes. Improving extension services and access to appropriate and affordable technology, rural credit schemes and marketing assistance, and breaking down trade barriers are other essential requirements for sustainable agricultural development.

Land tenure

Inequitable land distribution patterns are common in Africa — between genders, races and socio-economic classes as well as between private and state-ownership. Parts of the region also have inappropriate land ownership or land tenure policies, and this affects access to land and associated resources, as well as land management practices. In the Western Indian Ocean states, the best land is reserved for commercial crops mainly for export, while the poor and disempowered struggle to make a living from less productive, even marginal areas. South Africa presents an extreme example of inequitable land distribution. Due to apartheid policies abolished only recently, white farmers own 87 per cent of the land (Moyo 2000). The average amount of land held per person in South Africa is slightly more than 1 ha for blacks and 1 570 ha for whites (SARIPS 2000).

Conflicts over land have occurred for centuries but have become more frequent in recent years (most notably in Zimbabwe), especially since independence from European colonialism. During the past decade, there have been a number of land grabs and retrospective claims against the government, largely due to landlessness and displacements. Experiences with land reform in Africa are varied, and have had contrasting results. Some African countries embarked on land reform as early as the 1970s; for example, Kenya proceeded to privatize previously held customary land, resulting in speculation and the loss of land by some poor peasants (Quan 2000). Other countries including Botswana and Lesotho and, to some extent, Zambia have introduced leasehold arrangements in former customary lands to increase security of tenure. Market-driven land reforms have not achieved the desired effect of reducing inequalities, as is evidenced by the South African and Namibian experiences where the delivery of land to the disadvantaged black majority is proceeding at a very slow pace, while the prices of land are increasing.

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Land: Asia and the Pacific

The Asia and Pacific region covers about 23 per cent of the total land area of the Earth. The most critical land issues are degradation (including desertification), land use change and soil contamination. Population growth and high population density, poor land management practices, and emerging inequities in land and resource access have been the major driving forces for change over the past 30 years. Pressures behind degradation problems vary across the region. Overgrazing, overcropping and overuse of inorganic fertilizers are issues in most sub-regions while mining, logging, monocropping and alien invasive species have had dramatic outcomes in the Pacific Island countries (PICs).

Land degradation

Land degradation processes of particular concern in Asia and the Pacific include erosion, compaction, acidification, declining soil organic matter, weed infestation, soil fertility depletion and biological degradation.

The Global Assessment of Soil Degradation (GLASOD) estimated that about 13 per cent (or 850 million ha) of the land in Asia and the Pacific is degraded (Oldeman 1994) — most of this is in Asia but 104 million ha were estimated to be degraded in the Pacific sub-region where large-scale clearance of forest land has caused a decline in soil structure and fertility and where invasive species are the predominant land cover in many islands.

The most severe water erosion occurs in the Himalayas, Central Asia, China, the South Pacific and Australia, while the GLASOD study indicated that in the South Asian sub-region Afghanistan, India, Iran and Pakistan are the worst affected by wind erosion (Oldeman 1994).

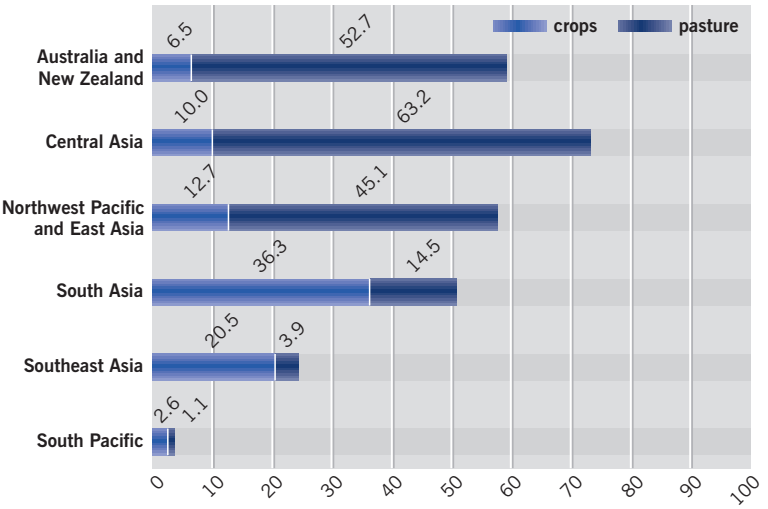
Chemical soil degradation is mainly caused by agricultural mismanagement. In parts of northern India and Bangladesh, soils have been acidified and salinized, and have been losing nutrients, while a significant proportion of land in Cambodia, Malaysia, Thailand and Viet Nam has been degraded by acid sulphates (Oldeman 1994). Poor soil nutrient balances (between phosphorus, nitrogen and potassium) are common in Australia, Bangladesh, Nepal, Pakistan and Sri Lanka.

Saline soils cover 60 million ha of agricultural land in the region, and Australia in particular is facing severe land salinization problems (MoAFFA 1999). Excessive extraction from groundwater and surface water sources, and rising water tables brought about by faulty irrigation systems, have increased the occurrence of surface water and soil salinity.

Serious soil contamination problems are characteristic of the northern parts of the region, and parts of Australia and New Zealand. The contaminants include cadmium (contained in fertilizer), hexavalent chromium, lead, arsenic, trichloroethylene, tetrachloroethylene and dioxin concentrates. Health issues arising from chronic poisoning from agricultural land were common in the 1970s in the northwest Pacific and northeast Asia (MoE Japan 2000). The major soil polluters in the region are now the chemical and electroplating industries in Japan and the Republic of Korea but heavy metals are also present in agricultural land (as a result of fertilizer application), and near mines and refineries (due to chemical discharges). Soil contamination from lead and arsenic contamination is prevalent throughout South and Southeast Asia. Irrigation with untreated effluent has also caused contamination and soil acidification in many areas; in Mongolia, for example, waste disposal and wastewater discharges are the main causes of soil contamination (UNDP 2000).

Actions taken to address soil contamination include Japan's Agricultural Land Soil Pollution Prevention Law which, as well as placing restrictions

Land utilization (percentage of total land area): Asia and the Pacific



Land is intensively cropped in South and Southeast Asia, with large areas of pasture in all other sub-regions except the South Pacific. In South Asia, more than one-third of all land is cropped

Source: compiled from FAOSTAT 2001

Removal of vegetation from Western Australia's farming areas has allowed groundwater to rise and salinization to set in

Source: UNEP, Peter Garside, Topham Picturepoint

on contaminating activities, has also instigated remedial projects. By 1999, remedial projects for 79 per cent of the total polluted land area (7 145 ha) had been undertaken (MoE Japan 2000). In the Republic of Korea, the Ministry of Environment established a Soil Contamination Monitoring Network in 1996 to prevent soil contamination adjacent to mines, refineries, military bases, oil storage facilities and waste landfills (Shin-Bom 1996). Australia now has a nationally consistent approach to the assessment of site contamination through the National Environmental Protection Measure (NEPM) for the Assessment of Site Contamination (NEPC 2001).

Many of the failures of physical responses to land degradation problems have stemmed from the competing influences of fiscal and market incentive programmes. The underpricing of resources and subsidization of agricultural inputs such as fertilizers have played important roles in maintaining pressures on land. A major policy failure leading to land degradation is insecure land tenure although in many cases even ownership is insufficient to ensure the sustainable use of land because population pressures have led to the fragmentation and overexploitation of land holdings. Competing economic and environmental policies have also influenced land use practices in New Zealand. Government subsidies in the 1970s and 1980s resulted in the conversion of large areas of forest and woodlands to pasture and crops, dramatically increasing the risk of erosion in these areas. However, since the removal of these subsidies in the 1980s, large areas of marginal pasture on steep land have been allowed to regenerate to scrub and native forest, reducing the risk of erosion (MoE New Zealand 1997).

Desertification

Of the 1 977 million ha of drylands in Asia, more than one-half are affected by desertification (UNCCD 1998). The worst affected area is Central Asia (more than 60 per cent affected by desertification) followed by South Asia (more than 50 per cent) and Northeast Asia (about 30 per cent).

Activities to combat desertification include watershed management, soil and water conservation, sand dune stabilization, reforestation programmes, reclamation of waterlogged and saline lands, forest and rangeland management, and soil fertility restoration.

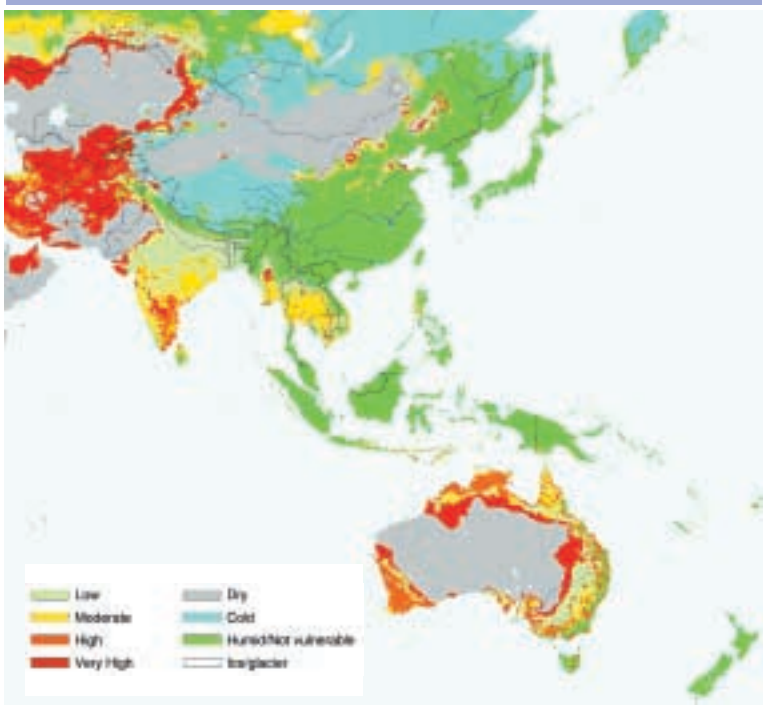
In India, programmes initiated since the early 1990s include the Afforestation Programme, Drought Prone Areas Programme (1994-95), Desert Development Programme, National Watershed Development Project for Rainfed Areas (1990-91), the Indira Gandhi Nahar Project (encouraging local community participation) and the Environmental Action Programme 1993 (MoEF India 2000).

Land use change

Land degradation problems are directly related to land-use practices, particularly agricultural expansion and intensification. Thailand's land use pattern has changed dramatically over the past 30 years, for example, as forest land declined from 56 to 24 per cent of total land area between 1965 and 1997 (Donner 1978 and GWF 1999). In Japan, the area of agricultural land decreased from 5.8 to 4.9 million ha between 1970 and 1999 as arable land was converted to residential use (NLA 2000).

Attempts to reduce land degradation by controlling land use change have met with little success. The consistent problem has been the inability to intervene with economic planning systems and the dominant sectoral approaches to land management. For the poorer countries, the priorities of jobs, employment and addressing stagnant economies have prevailed over integrated planning. In Australia, community voluntary initiatives starting in the early 1970s were given due recognition by government in 1988. The National Farmers' Federation and Australian Conservation Foundation jointly proposed the national land management programme called Landcare (Noble and others 1996). This proliferated in the mid-1990s to include Dune Care, RiverWatch, Bushcare and Coastcare programmes.

Desertification vulnerability: Asia and the Pacific



More than one-half of the region's drylands are affected by desertification — the worst affected area is Central Asia, followed by South Asia and Australia

Source: Reich and others 2001

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Land: Europe

The key issues associated with land resources in Europe are land-use planning in relation to agriculture and urban sprawl, and soil degradation due to factors such as contamination and erosion.

Steady population expansion, economic changes and economic growth over the past 30 years have led to competing demands on land for agriculture, forestry, environmental protection and recreation, and for urban and infrastructural development. The average annual rate of land cover change in Western Europe is quite small but at the local level changes can be significant, especially in densely populated areas — 74 per cent of the population of Europe is concentrated in only 15 per cent of its land surface (EEA 1999). At the same time, these areas experience high levels of activity in industry, transport, services and other economic sectors, with concomitant environmental problems.

Land use

Despite being a minority activity in terms of income and employment, agriculture is the dominant land use in Europe. Since the 1950s, Europe has experienced a continuing trend towards urbanization at the expense of natural, semi-natural and agricultural land. The area under productive agriculture in Western Europe has fallen over the past 30 years — by 6.5 per cent for arable and permanent crops and by 10.9 per cent for permanent pasture (FAOSTAT 2000). However, the decrease has been accompanied by more intensive production methods. This intensification trend seems set to continue, and better integrated spatial and land use planning and management are required to tackle the problems associated with land cover and land use change. During the 1990s, in many parts of Central and Eastern Europe, pressure on land resources began to decrease, due to the collapse of centrally planned economies, the ending of state subsidies to large collective farms and depopulation of rural areas. The economic collapse also led to a sharp decrease in the use of agricultural chemicals, abandonment of huge irrigation projects and agricultural land, and a decrease in numbers of livestock with a generally beneficial effect on the environment. A substantial land area is being reforested, and this trend may accelerate with climate change.

In recent years, increased attention has been given to the restoration and protection of wetlands. About two-thirds of the European wetlands that existed 100 years ago have been lost (EC 1999). Wetlands are the only ecosystem type that is covered by its own international convention, the Ramsar Convention of 1971, under which signatories agree to include wetland conservation in their national planning and to promote sound utilization of wetlands. In 1985, the World Wildlife Fund and the International Union for the Conservation of Nature launched a campaign to promote public awareness about wetlands and their importance. A major goal was to ensure that wetland development goes ahead only when all the implications are understood and when plans have been produced to ensure that the environmental consequences are minimized.

Policies and measures relating explicitly to land use planning and management have generally been the responsibility of national and local level governments in Western Europe, while in Central and Eastern Europe (CEE) there has been an abrupt change from central planning to local or no planning. Since 1989, the agricultural policies of CEE have gradually moved into line with those of the European Union. A number of international policy initiatives also exist relating to land management (see box below).

International efforts to improve land management

International policy efforts to protect ecosystems and wildlife habitats through global conventions include the Ramsar Convention on wetlands, the biodiversity convention and the European Spatial Development Perspective (ESDP) initiated by the Ministers responsible for Regional/Spatial Planning in the European Union.

The ESDP is intended to improve the spatial coherence of European Community (EC) policies. It examines both the achievements and the inadequacies of the main policy areas that affect the development of EC territory, including competition policy, policies linked to networks in transport and telecommunications, structural funds, agricultural and environment policy, and research, technology and development (EC Committee on Spatial Development 1999).

The Environment for Europe process also focuses attention on the European landscape. The European Biodiversity and Landscape Strategy was launched during the fourth Environment Ministerial Conference in Århus (1998).

These major international programmes all emphasize the need to improve statistical monitoring activities. The European Land Use/Land Cover Statistical Survey project (LUCAS) is a promising example which was approved by the European Parliament in April 2000.

The increase in sealed surfaces together with a decrease in forest cover has led to increased flooding — as here in Portugal — mudflows and landslides

Source: UNEP, Angelo Sande, Topham Picturepoint

Soil degradation

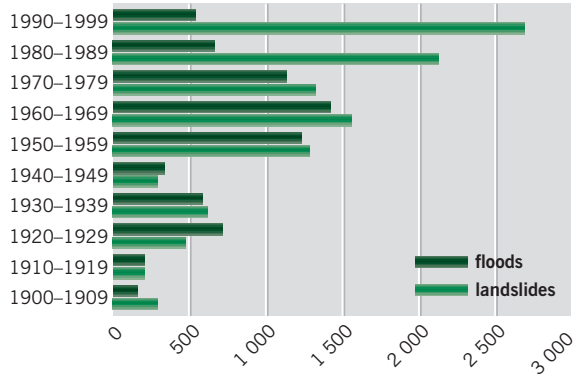
Damage to Europe's soils from human activities is increasing, including sealing of soil surfaces, local and diffuse contamination, and soil erosion. Despite the general recognition that soil degradation is a serious and widespread problem in Europe, it has not been quantified, and its geographical distribution and real extent are not accurately known.

The increase in sealed surfaces due to changes in land use together with a decrease in forest cover has increased the frequency and size of storm run-off, causing flooding, mudflows and landslides (EEA and UNEP 2000). Increases in damage from flooding have also resulted from the development of floodplains for industry and habitation.

Soil contamination occurs throughout Europe, although soil acidification from acid rain is no longer considered a major problem, having decreased by 50 per cent since the 1980s (EEA 1999). Contamination is particularly severe in urban areas due to industrial activities and inadequate waste disposal as well as in areas with a long tradition of heavy industry, mining and military activities and accidents. Throughout southeastern Europe, land which was already under stress from poor land management practices has been further damaged by military and refugee settlements, land mines (as much as 27 per cent of Bosnia's ploughed land is still mined) and other unexploded devices (REC 2000). In Eastern Europe huge irrigation and hydroelectric projects coupled with poor water management have resulted in salinization and waterlogging of large areas, especially in Azerbaijan, Belarus, the Russian Federation and Ukraine.

Soil erosion in Europe is mainly caused by water and is largely a result of unsustainable agricultural practices, clear cutting of forests and overgrazing. Soil erosion is most serious in the Mediterranean region. It has become irreversible (meaning a loss of more than 1 tonne/ha/year over 50-100 years) in some Mediterranean land areas and in the black soil regions of the Republic of Moldova, the Russian Federation and Ukraine. Erosion is a particular problem in the

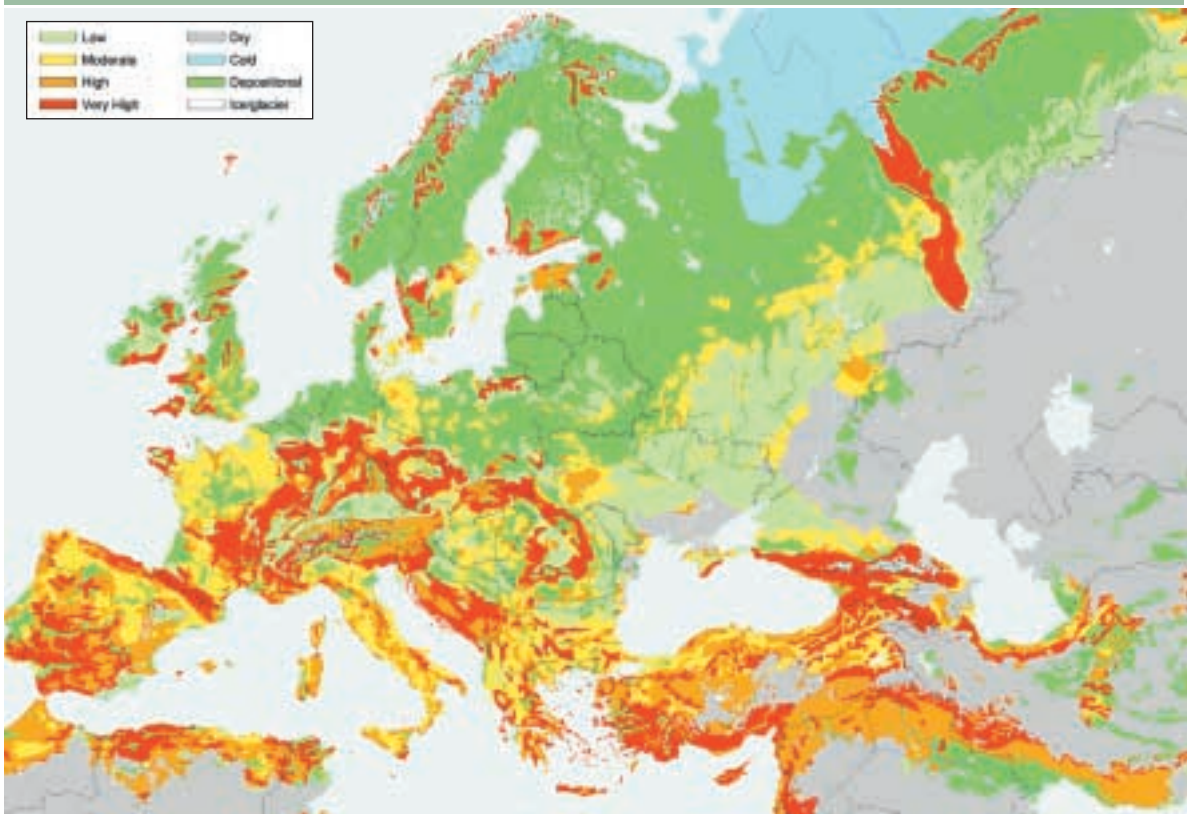
Floods and landslides in Italy (number of events)



In the past 20 years floods and landslides have affected more than 70 000 Italians and caused economic damage of nearly €11 000 million. Real impacts are underestimated since data are available for only a few events

Source: EEA and UNEP 2000

Water erosion vulnerability: Europe



Soil erosion in Europe is mainly caused by water and is most serious in the Mediterranean region and in the black soil regions of the Republic of Moldova, the Russian Federation and Ukraine

Source: USDA 2001

Commonwealth of Independent States: in 12 countries, 475 million ha (79 per cent) of agricultural land are affected by soil erosion to some degree (Interstate Statistical Committee 1999).

Unlike other media, no specific objectives and targets have been set for soil conservation, and it is rarely considered in sectoral planning activities such as transnational transport corridors. At the national level, some countries have produced legislation, policies and guidelines to ameliorate or prevent further soil degradation but policy measures are primarily aimed at combating pollution in other areas, and affect soils only indirectly. Statutory soil monitoring is carried out in a number of countries but rarely specifically for soil protection; policy performance can therefore not be quantified and comparability at the European level remains weak. The development of a common policy framework that recognizes the role of soil, aimed at sustainability, would have multiple benefits and improve Europe's environment as a whole.

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Land: Latin America and the Caribbean

The Latin America and Caribbean region has the world's largest reserves of arable land with an estimated 576 million ha equal to almost 30 per cent of the total territory (Gómez and Gallopín 1995). The region also contains 16 per cent of the world total of 1 900 million ha of degraded land, taking third place behind Asia and the Pacific and Africa (UNEP 2000).

Priority issues in the region include: loss of agricultural area (caused by factors such as erosion, changes in agricultural practices and growing urbanization); land degradation (associated with compaction, leaching of nutrients and pollution); and land tenure (covering inadequate and inequitable distribution of land as well as lack of tenure rights).

Expanding the agriculture and livestock boundaries

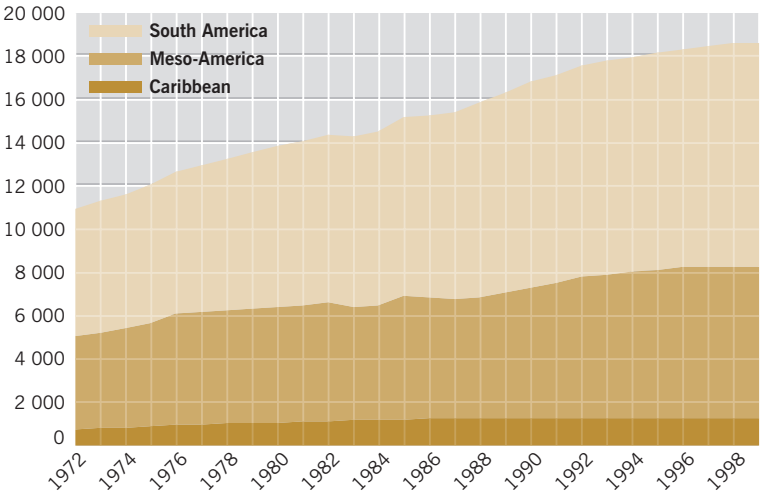
Agricultural expansion has intensified the use of natural resources and exacerbated many of the processes of land degradation. Over the past three decades, there has been an increase in arable land and grassland at the expense of forests. During 1972–99, the area of permanent arable land and cropland expanded in South America by 30.2 million ha or 35.1 per cent, in Meso-America by 6.3 million ha or 21.3 per cent and in the Caribbean by 1.8 million ha or 32.0 per cent (FAOSTAT 2001). The area under irrigation (see graph) also increased in the same period, resulting in greater agricultural production throughout the region. The expansion of permanent arable land on soils previously covered by forests is still the main cause of deforestation in the Brazilian Amazon (Nepstad and others 1999). Soybean production, mostly for export, has been the main driving force to expand the agricultural boundary in northern Argentina, eastern Paraguay and the central part of Brazil (Klink, Macedo and Mueller 1994).

The expansion of livestock production has also been a major driving force behind land conversion in the region. The process could not have been successful without the strong support of governments through the provision of tax incentives (the 'Legal Amazon' in Brazil), the construction of roads and the availability of skilled and cheap labour. For example, livestock companies in Bolivia leased land to peasants so that they could clear it for cultivation and then return it already cleared when their leases expired (Giglo 2000). Erosion, loss of nutrients, chemical pollution, salinization and the effects of meteorological and geological phenomena are major contributors to the different land degradation processes.

Land degradation

Erosion is the main cause of land degradation in Latin America, affecting 14.3 per cent of the territory in South America and 26 per cent in Central America (Oldeman 1994). Nutrient depletion is also a serious issue, largely driven by agricultural intensification.

Irrigated area (1 000 hectares): Latin America and the Caribbean



The irrigated area in Latin America and the Caribbean has expanded at an average of nearly 2 per cent a year over the period 1972–99

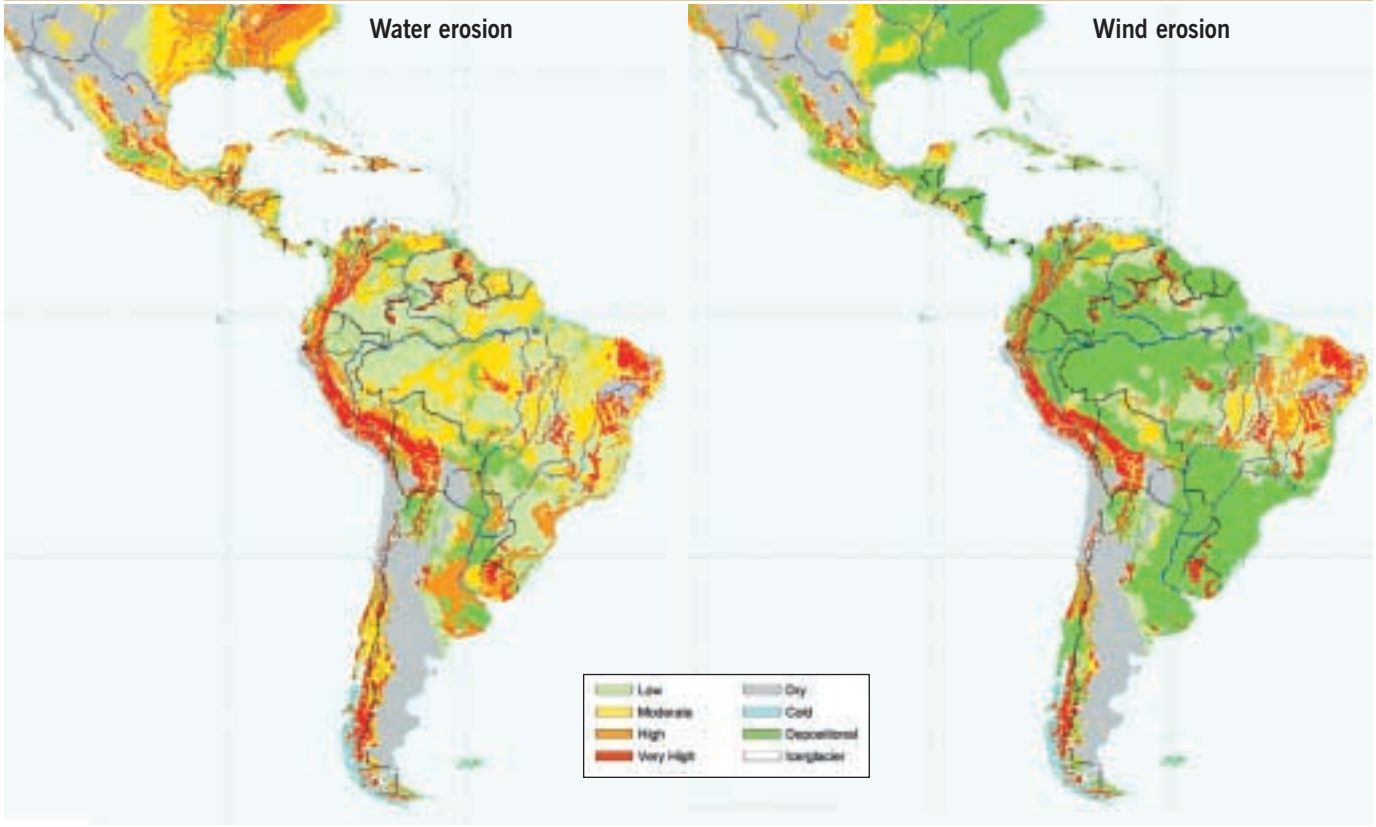
Source: FAOSTAT 2001

In South America, the depletion of nutrients from the soil had affected 68.2 million ha by 1980 (Scherr and Yadav 1997). This depletion has exacerbated poverty which, in turn, has contributed to greater environmental degradation and land deterioration.

Chemical soil pollution is increasingly significant given the intensification of agriculture and the use of pesticides during the past 30 years. Agricultural technology has increased production throughout the region but at a high cost to the environment. Of great concern is the impact of agrochemical pollution on soil and water and, as a consequence, on human health. Soil and water nitrification is linked to the use of chemical fertilizers which increased from 3.7 to 10.9 million tonnes during 1972–97 (FAOSTAT 2001).

Salinization is a particularly significant form of soil degradation because it is difficult to treat and can lead to desertification. Salinization caused by irrigation affects 18.4 million ha in the region, particularly in

Vulnerability to water and wind erosion: Latin America and the Caribbean



Erosion is the main cause of land degradation in the region, affecting 14.3 per cent of South America and 26 per cent of Meso-America

Source: USDA 2001a and 2001b

Argentina, Brazil, Chile, Mexico and Peru (AQUASTAT 1997).

The problems of land degradation have been discussed in regional and international fora for several decades. Following the 1992 United Nations Conference on Environment and Development, work on new conventions and agreements started to seek regional and sub-regional solutions. For example, the secretariat of the United Nations Convention to Combat Desertification (UNCCD), together with UNEP and the government of Mexico, established a Regional Coordination Unit for Latin America and the Caribbean to coordinate the work of national focal points in preparing national action programmes. These actions encouraged several countries to set up similar programmes and have led to the creation of monitoring systems (UNEP/ROLAC 1999, Universidad de Buenos Aires 1999). The Amazonian Pact, the Sustainable Development Commission, the Central American Integration System and the Andean Pact are examples of sub-regional mechanisms that have paved the way for agreements and have promoted monitoring and control systems to prevent land degradation.

Land tenure

Land tenure problems include the concentration of ownership in a minority of the population and a lack of land titles that has its historical origin in the colonial system of land ownership and the simultaneous existence of large agricultural holdings and smallholdings. About 38 per cent of the rural population are smallholders and they manage 35.1 per cent of the land under permanent cultivation (van Dam 1999). Average farm sizes range from 0.41 ha in Ecuador to a little more than 1.5 ha in Brazil and Peru.

In spite of the numerous agrarian reforms and land distribution schemes introduced in Latin America, land tenure has not changed markedly; there is both a tendency to merge farms to make larger holdings and an increase in the number of smallholdings (van Dam 1999). Both processes have adverse environmental effects. In large farms, the land suffers from erosion and compaction due to mechanization, as well as

salinization because of improper irrigation and chemical pollution. Smallholdings increase deforestation, and lead to erosion and loss of soil fertility because they are used intensively without allowing for adequate fallow periods (Jazairy, Alamgir and Panuccio 1992).

The Sub–regional Action Programme for Sustainable Development of the American Puna, under the UNCCD secretariat, is developing an action plan for an area where natural resources are limited and there are problems of increasing poverty, migration and marginality (UNEP/ROLAC 1999). The land tenure question, poor land regulations and the elimination of incentives for agricultural expansion inspired the programme.

Environmental impact of the land tenure regime on soil conditions in Jamaica

As in the rest of Latin America and the Caribbean, the land tenure regime in Jamaica is inequitable and, on both large properties and smallholdings, few land conservation and recovery methods are used.

In the 1970s, agrarian reform favoured large properties in the form of cooperatives, based on the intensified use of crops, mechanization, an increase in irrigated area and monocropping. The environmental effects included soil erosion and compaction of soils from mechanization, salinization caused by deficient irrigation systems and chemical pollution.

One-quarter of Jamaica's territory was under cultivation in the 1980s, and more than 90 per cent of farms covered 4 ha or less. These smallholdings were concentrated in ecologically fragile mountain areas of low fertility. Agriculture was based on traditional methods, including slash-and-burn cultivation. Physical infrastructure and basic services were lacking, farmers received little or no credit and had little schooling.

The continued expansion of large agricultural properties and the marginalization of peasant farmers has meant that there are now fewer fallow periods and less crop rotation. Deforestation of mountainsides continues and there has been a reduction in the number of draught animals. In zones with smallholdings, soil degradation tends to increase, especially the loss of fertility from erosion, and this is reflected in a marked drop in production.

Sources: van Dam 1999 and Library of Congress 1987

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Land: North America

About 11 per cent of the world's agricultural croplands are in North America, producing food, fibre and other products both for the region's own needs and for export. Almost 20 per cent of the United States is covered by arable and permanent cropland and 26 per cent by permanent grassland or pastures (OECD 1999). Although only 7 per cent of Canada's land is devoted to agriculture, this represents virtually all the undeveloped land that is amenable to cultivation (Environment Canada 1996). Land degradation, associated with agricultural expansion, intensification and industrialization, is a concern in North America. One of the key issues associated with land degradation is the use of chemical pesticides, which have contributed to increased food production but have also had important environmental and human health effects.

Conservation programmes

The US Conservation Reserve Program (CRP) was enacted in 1985 and expanded in 1990 to help farmers retire cropland that was environmentally sensitive or susceptible to erosion for 10 years in return for rental and cost-sharing payments and technical assistance. The aim was to reduce erosion and excess production. As of October 1999, 12.5 million ha of cropland were enrolled in the CRP (Zinn 1994, H. John Heinz III Center 1999).

In Canada, the Permanent Cover Program (PCP), first delivered in 1989 by the federal Prairie Farm Rehabilitation Administration, aims to reduce soil deterioration on cropland at high risk of soil damage by maintaining permanent cover of grass and trees. Although the programme has limited funds, only applies for a short period and restricts the amount of land each farmer can retire, some C$2-5 million of soil productivity has been saved by permanent cover on 320 000 ha of land (Tyrchniewicz and Wilson 1994, Vaisey, Weins and Wettlaufer 1996).

Land degradation

Some of the direct pressures leading to degradation have been agricultural expansion, intensification and overgrazing in arid lands (Dregne 1986, Gold 1999). These practices can cause erosion by water and wind, and chemical and physical degradation (Eswaran, Lal and Reich 2001). Socio-economic drivers include large federal subsidies, increasing global demand for agricultural products and increased trade liberalization (MacGregor and McRae 2000).

Lessons learned from the Dust Bowl experiences of the 1930s led to the adoption of soil conservation strategies such as contour ploughing, no-till methods, reduced summer fallow and increased crop residues. In the late 1970s and early 1980s, both countries reported on the status of their nation's soil. These reports led to the US Soil and Water Resources Conservation Act of 1977 and Canada's 1989 National Soil Conservation Program (Vaisey, Weins and Wettlaufer 1996, USDA 1996). They also adopted strategies that took fragile lands out of agricultural production to protect them from erosion (see box).

Conservation measures have led to significant declines in erosion over the past 30 years. In the United States, 30 per cent of croplands had highly erosion-prone conditions in 1982 compared to 24 per cent in 1992 (H. John Heinz III Center 1999, Huffman 2000, Padbury and Stushnoff 2000).

Data for other indices of land degradation are scarce: consistent US data for the national level of organic matter, the degree of soil compaction and the amount of land affected by salt are lacking (H. John Heinz III Center 1999). Conservation practices in Canada appear to have led to a decline in the rate of organic carbon loss from 70 kg/ha in 1970 to 43 kg/ha in 1990 (Smith and others 2000).

Desertification has generally been stabilized over the past 30 years as plant cover on rangelands has improved, and erosion and waterlogging have been controlled (Dregne 1986, UNCCD 2001). In the mid-1980s, salinization was estimated to affect about 25 per cent of the irrigated land in the United States, and conditions in heavily irrigated agricultural areas of the dry US southwest continue to worsen (de Villiers 2000). In Canada, only 2 per cent of agricultural land has more than 15 per cent of its area affected by salinity (Environment Canada 1996).

Historically, government agricultural policy focused on economic and production goals but sustainability has guided policy reforms in the recent past (MacGregor and McRae 2000). The Canadian Agri-Environmental Indicator project, completed in 2000, contributed to a more informed debate about agricultural sustainability, and the 1985 and 1990 US *Farm Bills* led to more sustainable stewardship by farmers and landowners (McRae, Smith and Gregorich

2000, NRCS 2000). In 1994, the US Task Force on Sustainable Agriculture set out recommendations to achieve environmentally and socially sound agricultural production and, two years later, the Federal Agriculture Improvement and Reform Act was signed expanding on earlier conservation themes (Gold 1999). The Canadian government set out its strategy for sustainable agriculture in 1997 (AAFC 1997).

Pesticides

North America accounts for 36 per cent of world pesticide use. By far the most common and widespread use of pesticides in North America is agricultural applications, which accounted for 77 per cent of US pesticide use in 1991 (Schmitt 1998). In Canada, the land area treated with chemical pesticides increased 3.5 times between 1970 and 1995 (Statistics Canada 2000).

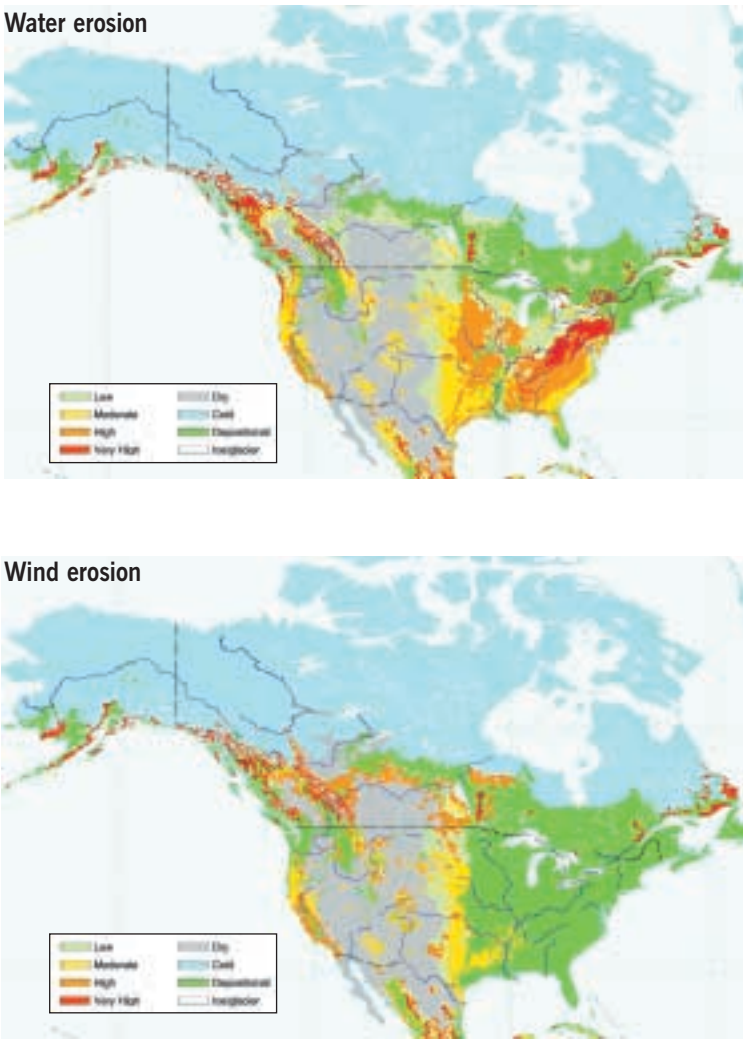
Since 1979, the total annual amount of pesticides used in the United States has remained fairly steady, while the use of insecticides has declined (Schmitt 1998). Reductions are due to safer pesticide products, new management techniques for controlling crop pests, and training and certification programmes for pesticide users (Fischer 2000).

Pesticides still pose a number of problems. Although the so-called 'soft' pesticides produced since 1975 are shorter-lived than POPs and do not accumulate, they are fast-acting and highly toxic to terrestrial and aquatic invertebrates in the short term. In some places, they have led to increased fish and wildlife kills (OECD 1996, Schmitt 1998). Pests have also become resistant. One report estimates that more than 500 insect pests, 270 weed species and 150 plant diseases are now resistant to one or more pesticides with the result that more frequent applications are needed today to accomplish the same level of control as in the early 1970s (Benbrook 1996).

With increased public concern about the health effects of pesticides and recognition of the special vulnerability of children and indigenous peoples living in the north, pesticide regulations in North America became more stringent during the 1990s. In 1996, the United States passed the 1996 Food Quality Protection Act and Canada's Pest Management Regulatory Agency was instituted in 1995 (OECD 1996, Cuperus, Berberet and Kenkel 1997, PMRA 2001). Heeding public demand to protect children from lawn pesticides, many North American municipalities now restrict pesticide use on public land and some have instituted total bans. Integrated pest management (IPM) initiatives have also been introduced (NIPMN 2000, Cuperus, Berberet and Kenkel 1997), allowing for greater flexibility than organic agriculture in which chemical pesticides are forbidden.

North America's soil conservation measures and its commitment to the continued phase out of POPs

Water and wind erosion vulnerability: North America



In spite of vulnerability, soil erosion in the United States declined by about one-third during 1987–97 and in Canada's agricultural regions the average number of days soil was left bare declined by 20 per cent during 1981–96

Source: USDA 2001a and 2001b

are positive trends. However, there is a lack of reliable data on soil erosion and other measures of land degradation, and improved tracking of pesticide use and impact monitoring are still needed. Strong legislation for point source pollution has diminished gross emissions to the land but it is now clear that more needs to be done to curb non-point pollution from agricultural inputs.

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Land: West Asia

Land degradation and, at its extreme, desertification, continue to be the most significant environmental issues in West Asia (CAMRE, UNEP and ACSAD 1996), especially in countries where the agricultural sector makes a significant contribution to the national economy. There is extensive desert in the region, ranging from 10 per cent in Syria to nearly 100 per cent in Bahrain, Kuwait, Qatar and the United Arab Emirates. Desertification has also affected wide areas of rangelands in Iraq, Jordan, Syria and the countries of the Arabian Peninsula. The causes include a combination of climate, high population growth rates and intensive agriculture. Poverty and inappropriate government policies exacerbate the problem.

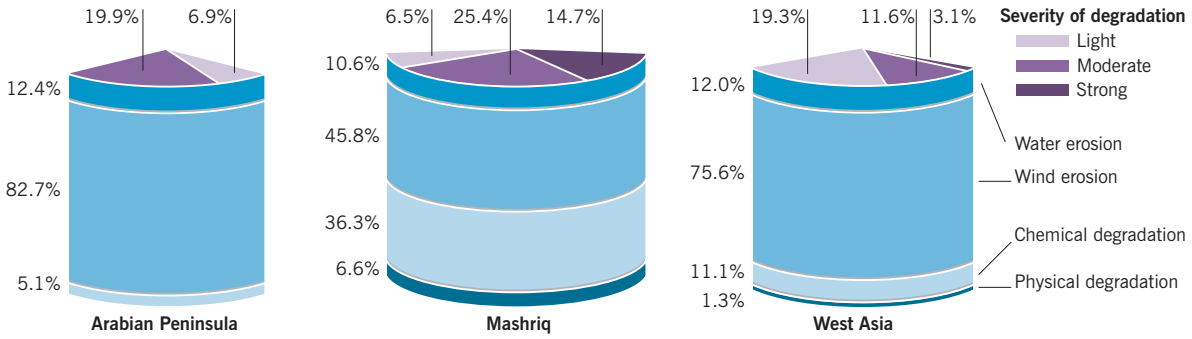
Geopolitical instability in and around the countries of West Asia has persuaded governments to adopt policies aimed at achieving national food security. These policies have been accompanied by agricultural protectionism, the erection of trade barriers and government subsidies for agricultural inputs. Subsidies, together with free or cheap irrigation water, have had severe impacts on land and water resources, and have contributed to the unsustainability of agriculture in the region (UNESCWA 1997). As a result, land degradation has become widespread, and it has accelerated as more rangelands were reclaimed and put under cultivation (CAMRE, UNEP and ACSAD 1996). The charts below show the extent and causes of degradation by sub-region.

Forest fires and forest clearance are two of the main causes of vegetation cover loss and soil erosion. Between 1985 and 1993, forest fires destroyed more than 8 000 hectares of forests and affected more than 20 000 ha of coastal forests in Syria, resulting in soil erosion in excess of 20 tonnes/ha/year. At the same time, nearly 2 440 ha of forest land were cleared for agricultural purposes (World Bank and UNDP 1998).

Population growth and other demographic changes have led to losses of land to urbanization, industrialization and non-agricultural purposes. Insufficient development and services in rural areas in the Mashriq sub-region and in Yemen have resulted in a rural influx to urban areas, spreading illegal settlements and squatter houses on the peripheries of major cities at the expense of fertile agricultural land. As well as encouraging intensification of agriculture, national policies aimed at achieving higher levels of food self-sufficiency also resulted in a more than two-fold increase in irrigated area between 1972 and 1999, from 2 991 million ha to 7 191 million ha (FAOSTAT 2001). The largest increase occurred in Saudi Arabia, from 0.437 million ha in 1980 to 1.6 million ha in 1993 (Al-Tukhais 1999). However, despite the large increase in the irrigated land area (see graph on page 86), the increase in food production has not kept pace with population growth.

Poor management and inefficient use of irrigation water have resulted in salinization, alkalization, water logging and nutrient depletion in large areas in the region. Salinization, which is the most important cause of degradation in irrigated soils, has affected about 42.5 per cent of the desert area in West Asia (Harahsheh and Tateishi 2000). About 2 million ha of the cultivated land area in Saudi Arabia and 33.6 per cent of cultivated land of Bahrain are moderately salinized (FAOSTAT 2001). Salinity and waterlogging have affected 8.5 million ha or 64 per cent of the total arable land in Iraq, while 20–30 per cent of irrigated land has been abandoned due to salinization (Abul-Gasim and others 1998). More than 50 per cent of the

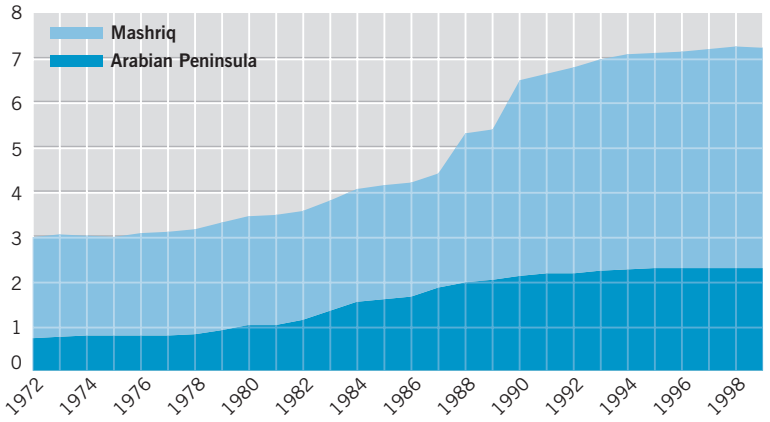
Land degradation in West Asia: severity and causes (%)



Charts left show the severity (percentage of total land area) and the causes (percentage of total degradation) for the region and the two sub-regions. Note the prevalence of wind erosion

Source: compiled from Marcoux 1996

Irrigated area (million ha): West Asia



Irrigated area in West Asia has grown sharply over the past three decades but agricultural production has not kept pace with population growth

Source: compiled from FAOSTAT 2001

irrigated lands in the Euphrates plains in Syria and Iraq have been badly affected by salinization and waterlogging (UNESCWA 1997).

Rangelands

Rangelands occupy about 50 per cent of the total area in West Asia. The vegetation cover is characterized by low tolerance, low plant density and coverage, and low species variability and plant productivity per unit area. Drought, overgrazing, uprooting of woody species for use as fuel, tillage, and mismanagement of water resources are the principal causes of rangeland deterioration. It is estimated that about 90 per cent of the rangelands are degraded or vulnerable to desertification. More than 30 per cent of the grazing land in Saudi Arabia is degraded (Shorbagy 1986, Al-Hassan 1991) and deterioration of rangelands has also been reported in several other countries of West Asia (Al-Kuthairi 1992).

The grazing intensity in most West Asian countries has more than doubled over the past four decades, mainly as a result of subsidized feeding, provision of water points and mechanization. Sheep density on some rangelands is more than one mature head per hectare — some four times the natural carrying capacity (Le Houerou 1995). It is estimated that the grazing capacity in the rangelands of the West Bank is exceeded by a factor of 5.7 (Palestinian Authority 2000).

Many West Asian countries are in the process of formalizing their national action plans to combat desertification. A Strategic Regional Action Plan to combat desertification in West Asia has been established within the framework of the UNCCD. Legislation has been enacted and laws and regulations regarding water and land use tightened. A number of range reserves have been established in the region.

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Land: the Polar Regions

The Arctic

The Arctic land mass is approximately 14 million km^2 (AMAP 1997), of which the Russian Federation and Canada account for nearly 80 per cent, the Nordic countries for around 16 per cent and the United States about 4 per cent (CAFF 1994).

The Arctic consists of three main sub-systems:

- the high polar desert in eastern Canada, which comprises mainly bare soils and rocks with sparse plant communities;
- the tundra, which is a vast, open plain with continuous low vegetation cover; and
- the forest-tundra, which is the transition zone that parallels the boreal forest to the south, and consists of patches of continuous forest cover interspersed with tundra-like open areas (CAFF 2001).

Besides its living resources, the Arctic contains huge deposits of oil, gas and minerals. In the Arctic regions of North America, there has been a recent upsurge of mining and associated infrastructural development. Likewise, in the Russian Federation — a country which covers 12.6 per cent of the Earth's land surface — much land has been seriously degraded by mineral extraction, forestry, fires, air pollution or conversion to agriculture, and erosion is widespread and increasing. In recent years, approximately 70 million ha of tundra have been degraded through destruction of soil and vegetative cover, resulting from prospecting, mineral development, vehicular movement, construction and, at certain locations, overgrazing by reindeer (OECD 1999).

The Russian Federation has established a solid legislative and regulatory base to respond to these threats. Unfortunately, implementation is not guaranteed due to the decline in the Russian economy, especially since 1998. Without an infusion of financial support to implement and enforce the legislative regime, the environmental situation will continue to decline (OECD 1999).

Along with increased resource exploitation, construction of roads and other infrastructure is also changing the face of the Arctic landscape.

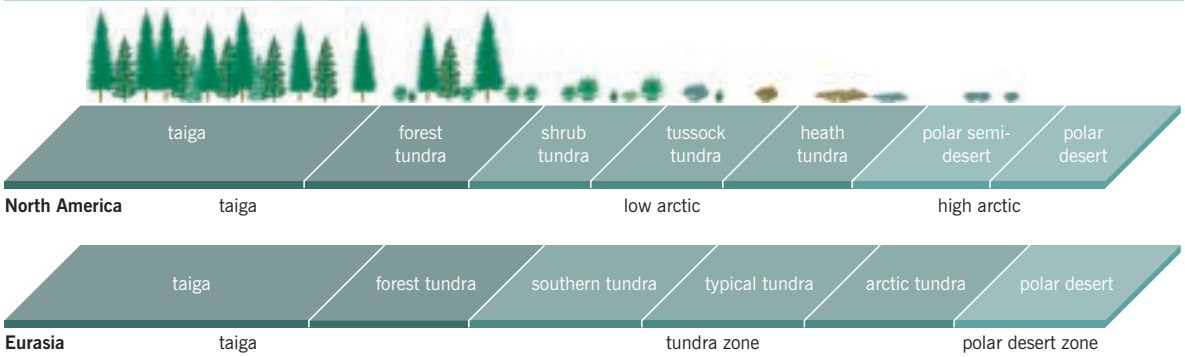
In Norway, for example, the area of undisturbed land has been reduced from 48 per cent in 1900 to 11.8 per cent in 1998. Norway is taking political action and is now placing increased emphasis on preservation of wilderness areas and to avoid piecemeal development (Nellemann and others 2001).

Tourism is growing in the Arctic and is already an important component of the economies of the north although it is still in its infancy in northern Russia. In 2000, more than 1.5 million people visited the Arctic (CAFF 2001). There are concerns, however, that tourism is promoting environmental degradation by putting extra pressures on land, wildlife, water and other basic necessities, and on transportation facilities.

Erosion is a serious problem in parts of the Arctic. It is caused by thawing, removal of ground cover and deforestation. In Iceland, for example, more than one-half of the vegetation and soil cover has been lost since the island was colonized by humans, especially in the interior, as a result of deforestation and overgrazing.

Arctic country governments have taken some action to protect their land base. Approximately 15 per cent of the Arctic land mass is protected, although nearly 50 per cent of the protected area is classified as Arctic desert or glacier — the least productive part of the Arctic and the one with the lowest biodiversity and habitat values (CAFF 2001).

Ecosystems in the Arctic



The Arctic is characterized by three main ecosystems: desert, tundra and the forest-tundra which is the transition zone

Source: CAFF 2001

Antarctica

The ice-free areas of Antarctica comprise less than 2 per cent of the total land area of the continent. These areas are largely found on the continental coastline (particularly in the Peninsula area) and on the islands south of 60°. The ice-free areas are biologically active sites with relatively easy access. They are therefore also the focus of increasing human activities and infrastructure. Threats to Antarctic land arise from this human activity, and threats to the ice sheets arise both as a result of this activity and, more importantly, from global climate change.

The risks associated with human uses of ice-free areas are related to potential local pollution due to oil spills, deposition of combustion products and sewage, habitat loss, terrain modification, disturbance to wildlife due to operations and human presence and introduction of exotic species and disease. However, so far little is known about the long-term and cumulative significance of these impacts.

There are now 70 research stations in Antarctica; half operate throughout the entire year and almost half are located in the Peninsula region (COMNAP 2000b). Few are located in ice-covered areas. Half of today's operative stations were constructed before 1970. In addition to this scientific activity, tourism in Antarctica is also increasing.

Ice covers 98 per cent of the Antarctic continent. The mass balance of this Antarctic ice sheet is of global concern, particularly in view of the impact on sea level of ice melting. The mass of ice is growing over most of East Antarctica although coastal regions tend to be near balance with some losses around some of the large ice shelves and coastal ice streams (Budd, Coutts and Warner 1998). The ice masses of Antarctica are therefore increasing rather than decreasing on a continental level (Vaughan and others 1999). However, the ice shelves in the Antarctic Peninsula continue to disintegrate because of regional warming. A total area loss of 6 300 km^2 was observed for the Larsen ice shelf between 1975 and 1998 (Skvarca and others 1999) and an additional 1 714 km^2 was lost during the 1998-99 season. Iceberg break-up is consistent with global warming but is not a proof of it. Melting of marginal ice shelves in the Antarctic Peninsula is, however, not expected to have significant and direct effects on sea level (IPCC 1998).

The Madrid Protocol on Environmental Protection

The Madrid Protocol on Environmental Protection to the Antarctic Treaty came into force in 1998. The signing of the protocol significantly strengthened the environmental objectives of the Antarctic Treaty. It requires, among other things, that all activities be planned and conducted so as to limit adverse impacts on the Antarctic environment and dependent and associated ecosystems. The Madrid Protocol also defines a framework for protected areas, enabling special protection of unique, important or especially vulnerable areas.

It is yet too early to assess the effectiveness of the provisions of the Madrid Protocol. However, some environmental measures adopted since the Protocol have already proved efficient. For example, in 1992 the National Antarctic operators developed guidelines for fuel handling and emergency response. Since then, a gradual decrease in the number of reported incidents per year has been recorded, indicating that these recommendations are being implemented and are effective (COMNAP 2000a).

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OUR CHANGING ENVIRONMENT: Habila, central Sudan

The Habila region was first developed for mechanized rain-fed agriculture in 1968. The intent was to use the fertile cracking clay soils that were not suited to traditional agriculture to address the region's chronic food supply problems, and eventually to produce surpluses for export.

Private investment was encouraged by the government and the land was divided into *feddans* (about 0.4 ha), which were then leased out to private operators. The original leases were to be left fallow after four years and new leases were to be let for adjacent fallow plots. The government controls were intended to ensure the continued viability and productivity of the cracking clay soils.

By 1979, about 147 000 ha were leased under official schemes, and the soils proved well suited to sorghum. However, in the 1970s Sudan launched a programme to become the bread basket of the Arab world. Production was greatly expanded, the proportion of fallow land decreased dramatically, and there was expansion into unsanctioned 'illegal' land.

By 1985, about 45 per cent of mechanized agriculture was located outside sanctioned areas. Farmers interested in quick profits cultivated the land to exhaustion, abandoned it and then recruited more.

By the mid-1990s, periods of persistent drought, internal warfare, unsustainable methods of land use and resultant famines plagued the country. The failed agricultural policy is clearly evident in the 1994 image. There is little evidence of the booming croplands so prominent in 1979.

Images: Chuck Larson, USGS/EROS Data Center
Compilation: UNEP GRID Sioux Falls