CHAPTER 3

Land


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Main Messages

Pressure on land resources has increased during recent years despite international goals to improve their management. The fourth *Global Environment Outlook* (UNEP 2007) highlighted the unprecedented land-use changes created by a burgeoning population, economic development and global markets. The outcome of those drivers continues to cause resource depletion and ecosystem degradation.

Economic growth has come at the expense of natural resources and ecosystems. Many terrestrial ecosystems are being seriously degraded because land-use decisions often fail to recognize non-economic ecosystem functions and biophysical limits to productivity. For example, deforestation and forest degradation alone are likely to cost the global economy more than the losses of the 2008 financial crises. The current economic system, built on the idea of perpetual growth, sits uneasily within an ecological system that is bound by biophysical limits. However, some market-based approaches that attach value to ecosystem services offer incentives to reduce environmental damage.

Competing demands for food, feed, fuel, fibre and raw materials are intensifying pressures on land. Demands for food and livestock feed are increasing rapidly due to human population growth and changing diets. Demand for biofuels and raw materials have also risen sharply, driven by the increased population, greater consumption and biofuel-friendly policies. This simultaneous growth is causing land conversion, land degradation and pressure on protected areas. Climate change is placing additional stress on productive areas. One result is heightened tension between goals related to production and those related to conservation.

Globalization and urbanization are aggravating competing demands on land. These processes expand and intensify the pressure on land systems by increasing the distances between places where products originate and where they are consumed. The greater distances can obscure the drivers of resource depletion and ecosystem degradation, produce higher environmental costs due to transport and infrastructure, and complicate the negotiation of sustainable land management practices. Large-scale international land deals are both an emerging outcome of and a contributor to this trend. Internationally coordinated responses are needed to address related social and environmental pressures.

Improved governance and capacity building are crucial to achieving sustainable land management. Many interventions meant to protect ecosystems have failed because they were created without recognizing local values or engaging local communities in their design and implementation. Capacity building across spatial and temporal scales is needed to improve land management. Current governance approaches include market-based strategies such as the collaborative UN programme for Reducing Emissions from Deforestation and Forest Degradation (REDD), centralized institutional strategies such as certification, and decentralized strategies such as community-based resource management. All offer both opportunities and challenges for improving land governance.

Potential exists to create more sustainable land systems. To solve these complex problems, it is critical to understand how diverse social and ecological drivers affect land systems at local, regional, national and global scales. A concerted effort by international organizations, the scientific community, and national and local institutions to coordinate their actions can create the policy options needed to achieve this goal.

INTRODUCTION

Changing climate patterns, economic globalization, population growth, increasing use of natural resources and rapid urbanization are putting pressure on terrestrial ecosystems as never before, and virtually all of them are under stress. Biophysical limits on what is available for human use are real and there are strong signals that these limits are close to being reached or have already been exceeded (Rockström *et al.* 2009). Even so, the fact that some areas show recent gains in forested area or land reclamation (Lambin and Meyfroidt 2010; Nepstad *et al.* 2009; Bai *et al.* 2008) suggests that declines are not inevitable, and indeed that recovery may be possible – even though original ecosystem functions may be modified or pressure on ecosystems may shift elsewhere (Meyfroidt *et al.* 2010).

Growing demands for food, feed, fuel, fibre and raw materials create local and distant pressures for land-use change (Lambin and Meyfroidt 2011). The cascade of outcomes resulting from these demands is complicated by urbanization and globalization, which separate the production of goods from their consumption over vast distances (Barles 2010; Kissinger and Rees 2010). The central question is how these demands can be met – or managed – in ways that recognize the joint imperatives of human well-being and environmental sustainability. Addressing this requires careful examination of the social relations and biophysical processes involved in managing terrestrial ecosystems, setting priorities for policies and policy instruments, and considering the likely distribution of implications, both positive and negative.

The fourth *Global Environment Outlook* (*GEO-4*) (UNEP 2007) noted that increased demand for water, waste disposal and food had led to unsustainable patterns of land use and land degradation. It identified forest cover and composition, cropland expansion, intensification of agriculture, desertification and urban development as key topics in land-use change. *GEO-4* concluded that continued inaction on land stewardship, combined with increased climate change, would reduce social resilience, making recovery from future stresses difficult or impossible. This chapter provides an update on the state and trends of global land systems including wetlands, explores major and emerging issues influencing changes in land use, examines the implications of recent changes for achieving international accords, and suggests some broad responses.

INTERNATIONAL GOALS

The international goals selected to guide this chapter cover vital targets related to food security, poverty reduction and environmental sustainability (Table 3.1). This chapter identifies biophysical, social, economic and political factors that may enable or constrain their attainment.

Table 3.1 Selected internationally agreed goals and themes related to land

Major themes from internationally agreed goals	Johannesburg Plan of Implementation (WSSD 2002) Paragraph 40b	Millennium Development Goal 1 (UN 2000)	Millennium Development Goal 7 (UN 2000)	World Food Summit Plan of Action (FAO 1996) Paragraph 33g	Ramsar Convention on Wetlands (1971)	United Nations Convention to Combat Desertification (UNCCD 1994) Article 2
Promote food security		X		X		
Reduce the proportion of people who suffer from hunger		X				
Improve access to food		X		X		
Increase food production		X				
Reverse the loss of environmental resources			X	X	X	X
Reduce the deforestation rate and increase forest coverage				X		
Halt the destruction of tropical forests				X		
Stem the loss of wetlands					X	
Combat desertification and mitigate the effects of drought						X
Practise integrated land-use planning and management	X		X	X	X	X
Integrate the principles of sustainable development into country policies and programmes	X		X			X
Recognize, maintain and develop the multiple benefits of ecosystem services (in addition to their economic value)				X	X	

The stakes are high: as Chapter 16 demonstrates, failure to achieve these targets could have severe impacts on human well-being and environmental integrity.

STATE AND TRENDS

This section uses selected indicators to gauge the current state of agricultural land, forests, drylands, wetlands, polar areas and human settlements, and recent changes to these land covers and uses.

Agriculture

Demands for food and livestock feed are rising rapidly due to population growth, urbanization and changing diets that include more animal products. One of the consequences of these changes is the widespread expansion of agricultural land allocated to livestock, both directly and indirectly through cropland dedicated to animal feed production (Rudel *et al.* 2009; Naylor *et al.* 2005). At a time when water shortage and land degradation remain threats to food security, accelerated interest in biofuel, feeds and fibre in recent years imposes competing demands on how agricultural land is used.

Box 3.1 Eradicating hunger

Related goals
Eradicate extreme poverty and hunger

Indicators
Proportion of malnourished people

Global trends
Proportion decreasing, but absolute number increasing

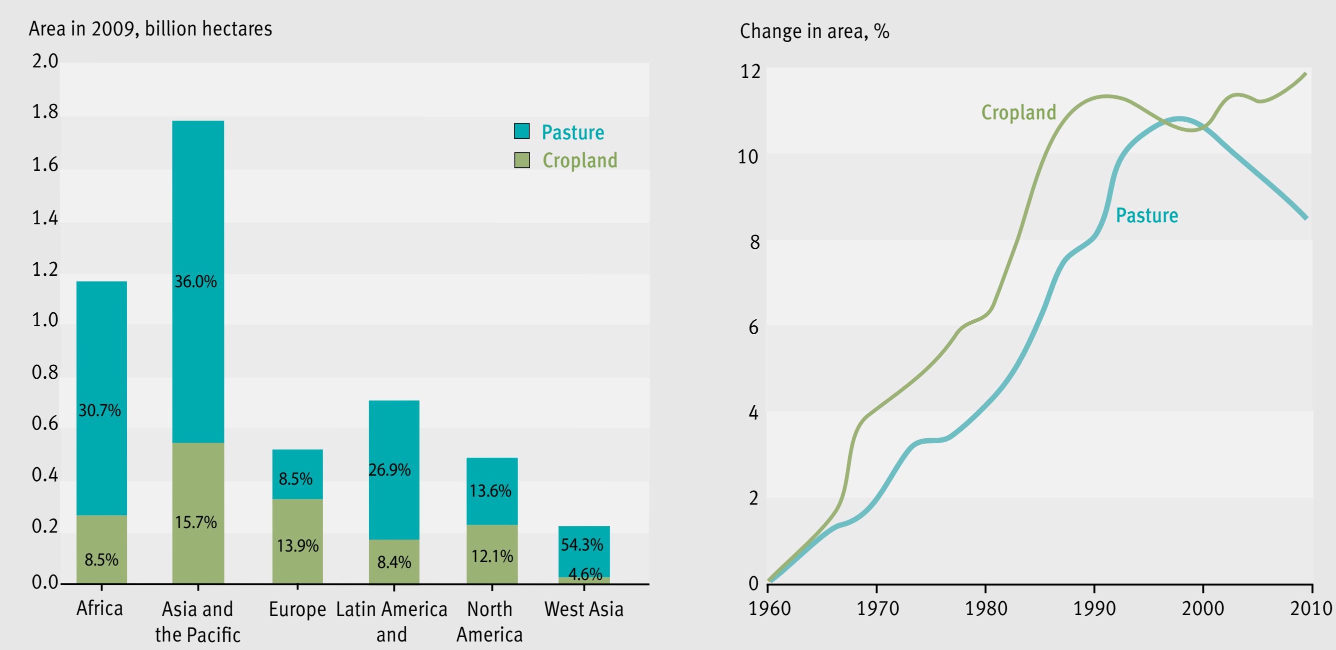
Most vulnerable communities
People who are food insecure due to chronic poverty, climate variation or food price fluctuations

Regions of greatest concern
Africa, Asia and the Pacific

Agricultural land and production trends

In 2009, there were approximately 3.3 billion hectares of pasture and 1.5 billion hectares of cropland globally, with the extent and proportion of total land area varying greatly across regions (Figure 3.1) (FAO 2012). In 2009, all regions except Europe had a greater proportion of land area devoted to pasture than to cropland. Although there has been only a slight increase in total cropland extent over the past decade, there has been a considerable change in the crops grown (Figure 3.2) (FAO 2012). Maize is an important crop in all regions other than West Asia, with the area harvested increasing by more than 25 per cent across Africa and Asia and the Pacific between 2001 and 2010. In total, approximately 160 million hectares of maize were harvested in 2010. Asia and the Pacific have the largest area of rice, but Europe and Africa experienced the greatest percentage increases between 2001 and 2010 – about 30 and 20 per cent respectively. The dominant soybean-producing regions are Latin

Figure 3.1 Area in use for cropland and pasture in 2009, by region, and global change between 1960 and 2010



Source: FAO 2012

Maize field in the foreground of an ethanol plant in Midwest United States, where the most common feedstock used for ethanol production continues to be maize. *© iStock/SimplyCreativePhotography*

America and the Caribbean and North America, with the United States, Brazil and Argentina the three largest producers. Asia and the Pacific and Europe are the primary producers of wheat.

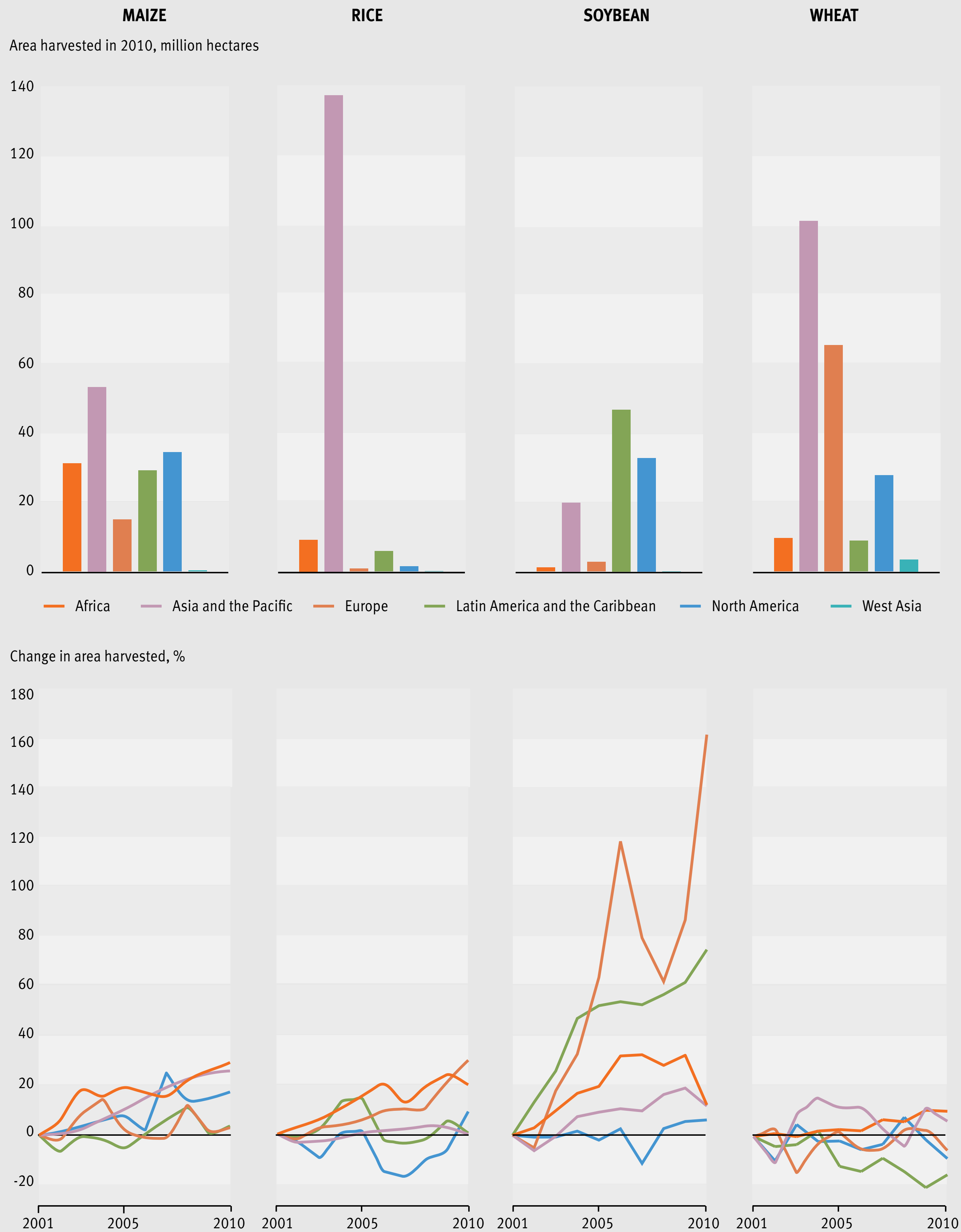
Increases in the area used for these crops have been accompanied by overall growth in yields (FAO 2012). Globally, the current yields of wheat, maize and rice have been estimated at 64, 50 and 64 per cent of their potential respectively, but the size of the yield gap varies greatly from region to region under the influence of different factors (Neumann *et al.* 2010). Larger gaps between actual and potential yields tend to occur where low-input agriculture is practised (Licker *et al.* 2010). Africa and Latin America and the Caribbean – two regions where crop area has expanded since 2001– still have relatively low yields compared to North America and Europe; if region-specific constraints can be assessed and overcome (Neumann *et al.* 2010), there may be potential to increase food production in these regions while minimizing cropland expansion.

Agricultural productivity is limited by biophysical and other factors. Extending conventional agriculture into uncultivated lands requires mechanization to modify the surface, and supplements in the form of fertilizers, herbicides, pesticides and irrigation water. Excessive use of machinery and chemical supplements, however, breaks up soil structure, increases erosion, chemically pollutes soil, contaminates groundwater and surface water, changes greenhouse gas fluxes, destroys habitat and builds genetic resistance to chemical supplements (Blanco-Canqui and Lal 2010; Foley *et al.* 2005; Buol 1995). With widespread adoption of intensive, mechanized, high-input agricultural practices, the rate of soil erosion has greatly increased. Erosion in conventional agricultural systems is now over three times higher than in systems practising conservation agriculture, and over 75 times higher than in systems with natural vegetation (Montgomery 2007). Globally, soil erosion is contributing to the decline in agricultural land available per person (Boardman 2006) as degraded land is abandoned (Bakker *et al.* 2005; Lal 1996). Thus, the yield gains achieved by these methods come with ecological costs.

In continuously cultivated, low-input agricultural systems, rapid declines in soil fertility and yield, together with international commodity price changes, continue to impact human well-being in agricultural communities (Koning and Smaling 2005). Sustainable intensification techniques offer the potential to improve soil fertility and yields in some situations while avoiding some of the problems of high-input agriculture just presented.

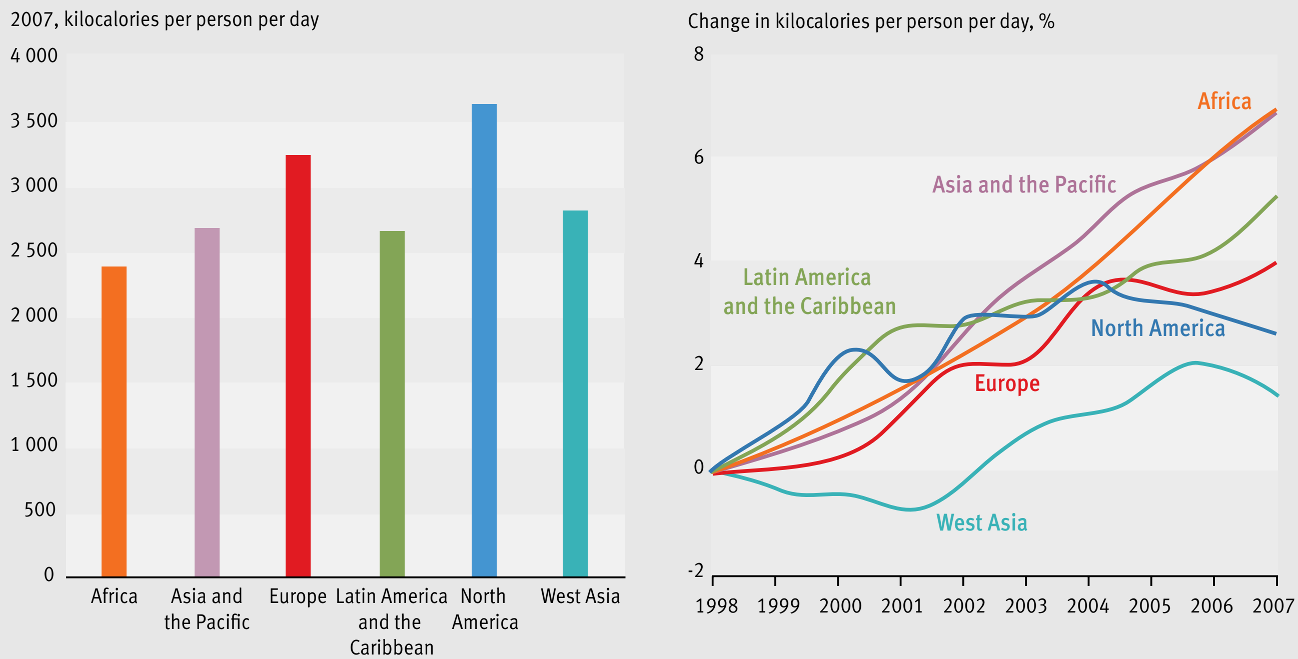
While the future impact of climate change on global food production is difficult to specify, substantial evidence suggests that an increasing number of people will be directly affected by climate change impacts on agricultural areas (World Bank 2010).

Figure 3.2 Area harvested in 2010 and the change between 2001 and 2010, selected crops



Source: FAO 2012

Figure 3.3 Average food supply in 2007 and the change between 1998 and 2007, by region



Source: FAO 2011

Consumption trends

While the proportion of undernourished people has been declining – from 14 per cent of world population in 1995–1997 to 13 per cent in 2010 – the absolute number rose over the same period from 788 million to an estimated 925 million due to population growth (Box 3.1) (FAO 2010b). Areas with chronic food insecurity face many obstacles, including regional conflicts, weak governance structures and a breakdown of local institutions, all of which affect access to and distribution of food (FAO 2010a). Many of the world's undernourished people live in areas that are also particularly vulnerable to climate variability. Africa and Asia and the Pacific were the regions with the lowest average food consumption in 2007 (Figure 3.3) (FAO 2012), but they were also the regions that had experienced the highest percentage increase. While the Asia and Pacific region is home to the largest number of undernourished people, at 578 million, sub-Saharan Africa has the highest proportion of undernourished people – about 30 per cent of its population in 2010 (FAO 2010b).

Forests

Forests play a crucial role in terrestrial ecosystems and provide a multitude of services such as shelter, habitats, fuel, food, fodder, fibre, timber, medicines, security and employment; regulating freshwater supplies; storing carbon and cycling nutrients; and helping to stabilize the global climate. Historically, forests have been under pressure due to increasing demands for shelter, agricultural land, meat production, and fuel and timber extraction, but in recent decades this pressure has increased due to competing demands for agricultural expansion and biofuel production, rapid urbanization and infrastructure development, and increased global demand for forest products. Forests are also under increasing stress from changes in mean annual temperatures, altered precipitation patterns, and more frequent and extreme weather events (Allen *et al.* 2010; Tiwari 2009).

Box 3.2 Forests

Related goals
Reduce deforestation and increase forest cover

Indicators
Net forest change

Global trends
Some forest gains in temperate areas; deforestation slowing in some tropical countries; overall tropical deforestation remains high

Most vulnerable communities
Forest-dependent people in tropical countries

Regions of greatest concern
Africa, Latin America and the Caribbean

Forest area

Forests cover just over 4 billion hectares, 31 per cent of the world's total land area (FAO 2011). The majority of these are boreal forests extending across northern and central Russia and much of Canada and Alaska. Large expanses of tropical forest are found in the Amazon, Africa's Congo Basin and parts of South East Asia. Temperate forests remain in a patchy distribution across the United States, Europe and the Asian mid-latitudes.

The rate of forest loss from both deforestation and natural causes is slowing, but remains alarmingly high (Box 3.2). At the global level, annual forest loss decreased from 16 million hectares in the 1990s to approximately 13 million hectares between 2000 and 2010 (FAO 2011). The highest rates of tropical forest loss over this period occurred in South America and Africa (Figure 3.4). Some rapidly developing countries that suffered extensive deforestation in the 1990s, including Brazil and Indonesia, have significantly reduced their rates of tropical forest loss (FAO 2011; Ometto *et al.* 2011), while less developed nations in Latin America and Africa continue to experience high rates of loss. Although much of the developed world has experienced net reforestation since the late 1800s as a result of rural-urban migration and farm abandonment (Walker 1993; Mather 1992), natural factors such as drought, forest fire and insect attacks have exacerbated forest loss in recent decades. However, the key drivers of forest loss are population growth, poverty, economic growth, land pricing, international demand for timber and other forest products, insecurity of the rights of local people, and incomplete valuation of forest ecosystems (Carr *et al.* 2005; Lambin *et al.* 2001).

Clearance in the Amazon, where a substantial portion of deforestation is attributed to cattle ranching and large-scale soybean production.
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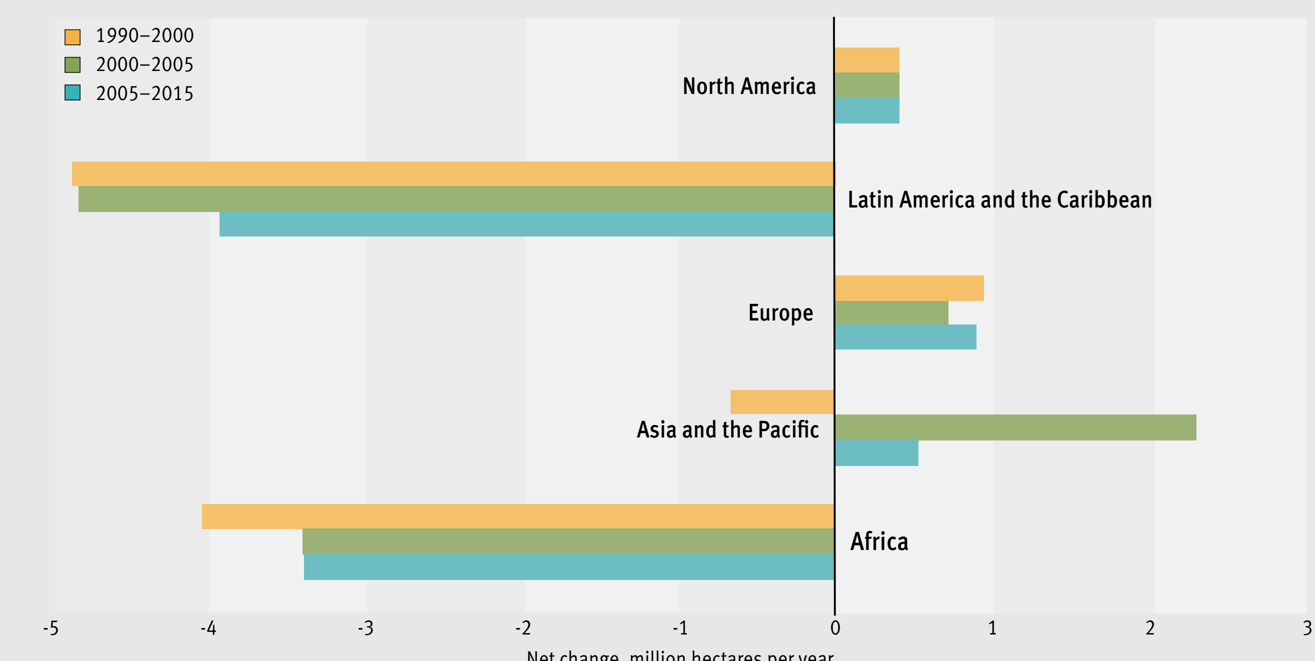
Plantations

Forest plantations, generally cultivated for industrial purposes, increased by 50 million hectares globally between 2000 and 2010, reaching 264 million hectares or 7 per cent of the total forest area (Table 3.2) (FAO 2011). Asia accounted for 28 million hectares, or 58 per cent of this increase. Generally, monoculture plantations tend not to enrich local biodiversity, but they do provide ecosystem services including timber, carbon and water storage and soil stabilization.

Figure 3.4 Change in forest area by region, 1990–2010



Source: UNEP 2011c; FAO 2010a

Table 3.2 Plantation area in 2010 and the increase between 2000 and 2010, by region

	Africa	Asia and the Pacific	Europe	Latin America and the Caribbean	North America	West Asia	World
Plantation area 2010, thousand hectares	15 409	121 802	69 318	14 952	37 529	5 073	264 084
Annual increase, thousand hectares	245	2 948	401	407	809	115	4 925
Annual increase, %	1.75	2.82	0.6	3.23	2.46	2.6	2.09

Note: FAO data has been applied to GEO regional categories, except for Afghanistan, Turkey and Iran, which are included in West Asia.

Source: FAO 2011

Productive and protective forest area

The global forest area designated for the production of timber and non-timber products declined from about 1.16 billion hectares in 2000 to about 1.13 billion hectares in 2010, an annual decrease of about 2.91 million hectares or 0.25 per cent (FAO 2011). However, the global forest area designated for protection of soil and water increased from about 272 million hectares in 2000 to about 299 million hectares in 2010, an annual increase of some 2.77 million hectares or 0.97 per cent (FAO 2011). Similarly, the global forest area designated for biodiversity conservation has increased from around 303 million hectares to about 366 million hectares, an annual increase of about 6.33 million hectares or 1.92 per cent (FAO 2011). The main reason for the decrease in forest area designated for production is deforestation, and for the increase in protective forest area is afforestation (FAO 2010a).

Forest management and certification

The Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) are the two main forest management certification organizations. There was an increase in certified forests of about 20 per cent per year between 2002 and 2010 under these two agencies (UNEP 2011c). However, in 2010 about 10 per cent of the total forest area was under FSC- or PEFC-certified forest management (UNEP 2011c). These trends indicate that while there is improvement in forest management, much work remains to be done.

Forest carbon stock

Forests are considered an important sink for atmospheric carbon dioxide (CO_2) because of their ability to store carbon in their biomass and soil (Anderson *et al.* 2011). More than 75 per cent of the total terrestrial biomass carbon stock and more than 40 per cent of the soil organic carbon stock are found in forest ecosystems (Jandl *et al.* 2007). In the 1990s, forest carbon sequestration was equivalent to approximately one-third of carbon emissions from fossil fuel combustion and land-use change (Bonan 2008). Boreal forests store more carbon in their soils than tropical forests, while tropical forests store much more carbon in their plant biomass (Prentice *et al.* 2001). Pan *et al.* (2011) estimate that global forest systems constituted a total carbon sink of 2.4±0.4 billion tonnes of carbon per year from 1990 to 2007.

Fires are a major source of greenhouse gas emissions from forests (van der Werf *et al.* 2010). Boreal forest ecosystems are prone to frequent and severe wildfires leading to large carbon emissions. Amiro *et al.* (2001) estimated that during the period 1949–1999, on average 2 million hectares of the Canadian boreal forest burnt annually (ranging from 0.3 to 7.5 million hectares in any given year), emitting a yearly average of 27±6 million tonnes of carbon (ranging from 3 to 115 million tonnes in any given year). Sukhinin *et al.* (2004) estimated that on average 7.7 million hectares of area burnt annually between 1995 and 2002 in eastern Russia and that 55 per cent, 4.2 million hectares, of that area was forest. Gillett *et al.* (2004) found that recent increases in area burnt in Canada are a result of anthropogenic climate change. In the future more fires, more area burnt and longer fire seasons may be expected in temperate and boreal regions (Flannigan *et al.* 2009).

Drylands, grasslands and savannahs

Drylands, grasslands and savannahs experience high spatial and temporal variability in rainfall, resulting in dramatic differences in plant growth, habitats and human livelihoods. Drylands cover approximately 40 per cent of the world's land surface and are home to more than 2 billion people, 90 per cent of whom are in developing countries (UNEP 2007). However, the spatial extent of drylands remains uncertain due to variations in ecosystem sub-types, data variability and the different classes and thresholds applied to remotely sensed data, making global comparisons challenging (Reynolds *et al.* 2007). Grasslands range from very dry, almost desert-like, to humid types. Savannahs are mixed tree-grass ecosystems, ranging from almost treeless grasslands to closed-canopy woodlands that occupy large areas in the tropics and sub-tropics, particularly in Africa, Latin America and Australia (Mistry 2000).

Trends in drylands, grasslands and savannahs

Fluctuations in precipitation are a major driver of change in plant cover, but grazing intensity has also been directly linked to long-term dryland degradation (Miehe *et al.* 2010). Transformation of rangelands to cultivated croplands is leading to a significant, persistent decrease in overall dryland plant productivity. Sietz *et al.* (2011) indicated that the most important factors causing vulnerability in drylands are water stress, poverty, soil degradation, natural agronomic constraints and isolation from political centres.

Net primary productivity (NPP) is the net amount of carbon captured by vegetation through photosynthesis each year (Melillo *et al.* 1993). Approximately 2 per cent of global terrestrial NPP is lost yearly due to dryland degradation, equivalent to 4–10 per cent of dryland potential NPP (Zika and Erb 2009). Figure 3.5 shows how dryland degradation, measured in terms of NPP loss, is most widespread in the Sahelian and Chinese arid and semi-arid regions, followed by the Iranian and Middle Eastern drylands and to a lesser extent the Australian and Southern African regions. Sustainable development in drylands will rely on techniques that improve soil fertility, conserve soil and water and increase agricultural efficiency, such as mulch farming, conservation tillage and diverse cropping systems (Mortimore *et al.* 2009).

Figure 3.5 Global extent of drylands and human-induced dryland degradation

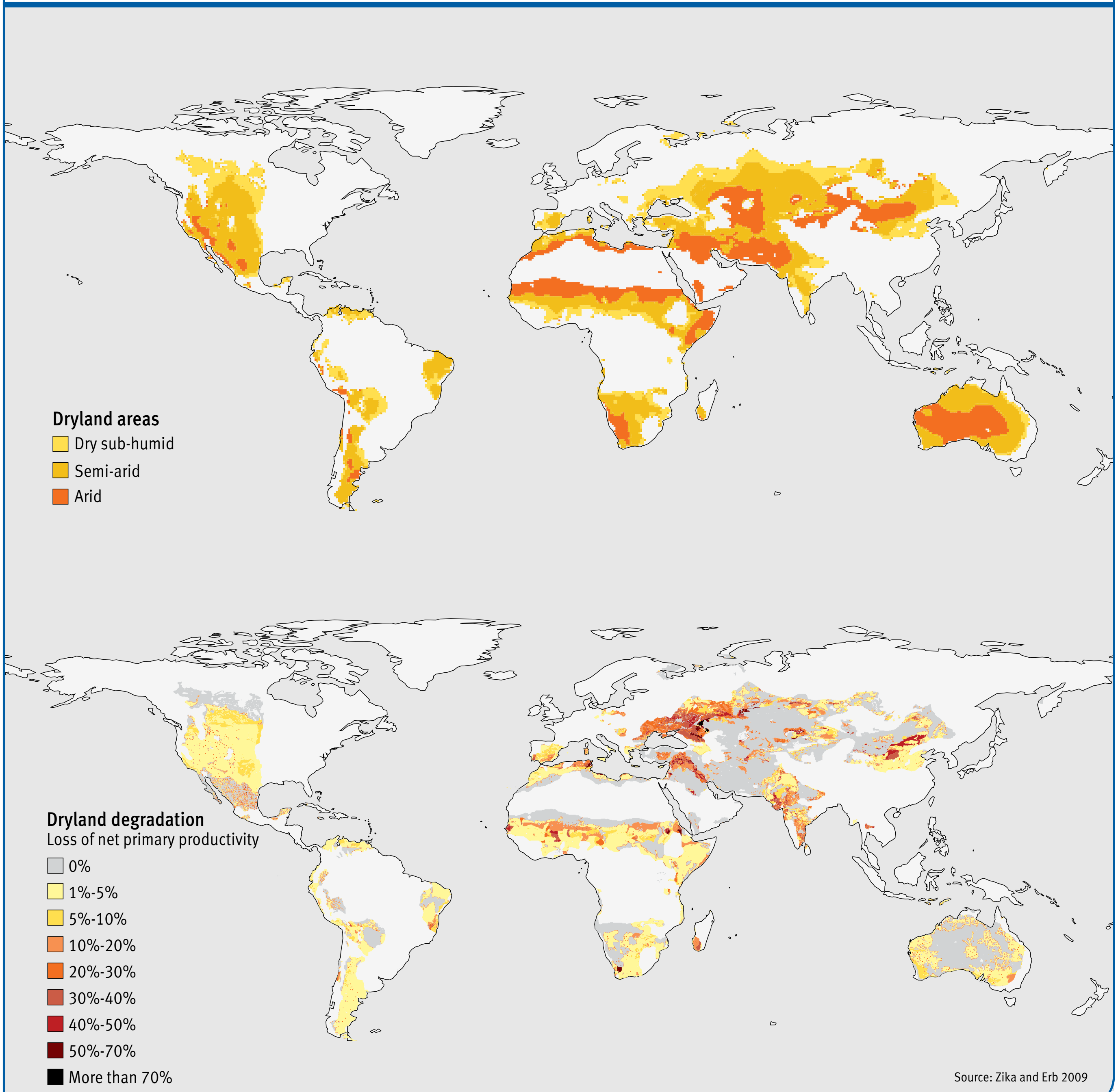


Figure 3.6 UNCCD operational objectives and achievements, 2010

Operational objective	Performance indicator	Current achievement level	Overall target	Target due
Advocacy, awareness and education	Information and awareness	25%	**30%** of global population informed about desertification, land degradation and drought and/or synergies with climate change and biodiversity	2018
Policy framework	National action plan alignment	5%	**80%** of affected country Parties with a formulated/revised national action plan aligned to the 2008–2018 Strategic Plan	2014
	Joint planning of the Rio conventions*	72%	**100%** of affected country Parties with joint national action plans in place or functional mechanisms to ensure synergies between the three Rio conventions	2014
Science, technology knowledge	Dryland monitoring	38%	**60%** affected country Parties with established and supported national dryland monitoring systems	2018
Capacity building	Dryland capacity-building	71%	**90%** of affected country Parties implementing dryland-specific capacity-building initiatives	2014
Finance and technology transfer	Integrated investment framework	15%	**50%** of affected country Parties with integrated investment frameworks	2014

* Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCCC) and United Nations Convention to Combat Desertification (UNCCD)

The figure evaluates progress towards the UNCCD targets, showing substantial progress in some areas and highlighting a need for improvement in others. Particularly encouraging is the high level of awareness about dryland degradation globally. Challenges have been encountered in aligning national action plans and developing integrated investment frameworks. The assessment process has also revealed problems in data availability and reporting methods (UNEP-WCMC 2011), potentially enabling UNCCD to address these lessons learnt prior to the next reporting cycle in 2012.

Source: Prepared by UNEP-WCMC

As an international response to desertification, land degradation and drought in drylands, the United Nations Convention to Combat Desertification (UNCCD) was adopted in 1995 and has since been signed by 194 Parties – 193 countries plus the European Union. Following mixed results in its initial implementation phase (UNCCD 2007), Parties to the Convention adopted a ten-year strategic plan for 2008–2018 to revitalize it. The plan includes a results-based management approach built on a set of specific objectives and indicators, and a new monitoring, assessment and reporting process – the performance review and assessment of implementation system.

Wetlands

In 2003, the European Space Agency, in collaboration with the secretariat of the Convention on Wetlands of International Importance (Ramsar Convention), launched the GlobWetland project to demonstrate the current capabilities of Earth observation technology to support inventorying, monitoring and assessment of wetland ecosystems. The project revealed a major gap between the findings of the Earth observation and wetland communities (Jones *et al.* 2009), with considerable inconsistency in global wetlands estimations (Table 3.3).

The conversion of wetlands continues. For both inland and coastal wetlands, the most salient drivers of change are population growth and increasing economic development, which in turn promote infrastructure development and land conversion including agricultural expansion (Wood and van Halsema 2008). Other direct drivers affecting wetlands are deforestation, increased withdrawal of freshwater, diversion of freshwater flows, disruption and fragmentation of the landscape, nitrogen loading, overharvesting, siltation, changes in water temperatures and invasion by alien species (Fraser and Keddy 2005). In 14 deltas analysed by Coleman *et al.* (2008), over

Table 3.3 Estimates of global wetland area

Region	Global review of wetlands resources (MA 2005b; Finlayson *et al.* 1999)		Global lakes and wetlands database (Lehner and Döll 2004)	
	Million hectares	% of global wetland area	Million hectares	% of global wetland area
Africa	125	10	131	14
Asia	204	16	286	32
Europe	258	20	26	3
Neotropics	415	32	159	17
North America	242	19	287	31
Oceania	36	3	28	3
Total	1 280	100	917	100

half of the studied wetland area of 1.6 million hectares had been irretrievably lost over a 14-year period due to natural causes, conversion to agriculture or industrial use. Global climate change may exacerbate the loss and degradation of coastal wetlands. For example, Syvitski *et al.* (2009) analysed the effects of human activities on delta subsidence, susceptibility to flooding and vulnerability to sea level rise, concluding that the area of deltas at risk of flooding could increase by more than 50 per cent by the end of this century.

The deforestation, drainage and conversion to agriculture of peatland results in substantial emissions of CO_2 and nitrous oxide (Mitra *et al.* 2005). Globally, peatlands cover 3 per cent of the world's land surface, about 400 million hectares, of which 50 million hectares are being drained and degraded, producing the equivalent of 6 per cent of all global CO_2 emissions (Crooks *et al.* 2011). Avoiding further wetland degradation could result in significant climate change mitigation (Wetlands International 2011).

Because of increasing demand for land for food, feed, biofuels and materials, the loss of wetlands and associated ecosystem services is likely to continue (CA 2007). Globally, coastal wetlands such as mangroves are continuing to decline by more than 100 000 hectares, over 0.7 per cent, per year, but that rate of loss has slowed relative to the 1 per cent per year of the 1980s. Although, in most regions, rates of loss have decreased compared to the 1980s and 1990s, mangrove losses in Asia accelerated again during 2000–2005 (UNEP-WCMC 2010). Despite these losses, the Asia and Pacific region holds the largest spatial extent of mangrove systems – more than 50 per cent of the global total. Other major mangrove areas are in northern Latin America, Eastern and Western Africa, and the Red Sea.

Polar regions

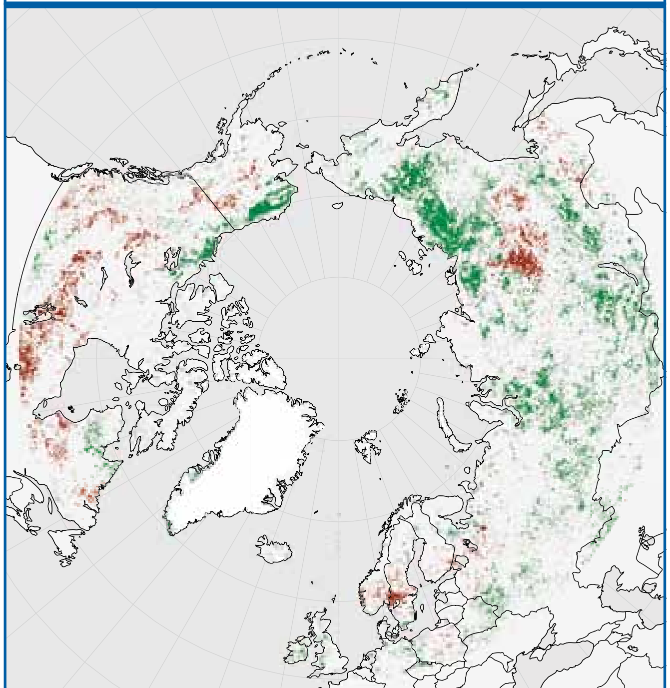
The Arctic's permafrost – the top 3.5 metres of soil that remains permanently frozen for 24 months or more – contains the largest deposits of organic carbon on Earth. But due to some of the most rapid warming on the planet (McGuire *et al.* 2009; Tarnocai *et al.* 2009), with temperatures in the permafrost having already risen by up to 2°C over the past two to three decades (AMAP 2011), this is likely to become a substantial source of carbon emissions over the next century (Schuur *et al.* 2008). The Arctic's tundra and boreal forest ecosystems currently act as a carbon sink (McGuire *et al.* 2009), but it is possible that the Arctic region will become a net emitter over the course of the 21st century (Schuur *et al.* 2008; Zimov *et al.* 2006) as up to 90 per cent of near-surface permafrost is expected to disappear due to thawing by 2100 (Lawrence *et al.* 2008).

Methane emissions, primarily from wetlands, also play an important role in the carbon balance of the Arctic (O'Connor *et al.* 2010). Although just 2 per cent of global methane emissions originate in the Arctic, this region has seen the largest proportional increase in emissions, rising by nearly a third between 2003 and 2007 (Bloom *et al.* 2010). Some of these emissions originate in the escape of methane from sequestration within hydrate crystals frozen beneath permafrost. These methyl hydrates also occur in abundance beneath the deep ocean floor and within continental shelves (O'Connor *et al.* 2010). Methane is 25 times more effective at trapping heat in the atmosphere than CO_2 over a 100-year horizon (IPCC 2007).

Other climate-related land changes occurring in the Arctic include the northward movement of tree lines, woody vegetation encroachment into the tundra, and a longer growing season – resulting in an increase in plant productivity (Figure 3.7) (Epstein *et al.* 2012; Walker *et al.* 2012; Callaghan *et al.* 2011; Wang and Overland 2004; Zhou *et al.* 2001; Myneni *et al.* 1998). Whilst these processes remove CO_2 from the atmosphere, it is likely that the release of carbon from thawing permafrost and other processes will outpace CO_2 sequestration by vegetation (Schuur *et al.* 2008; Zimov *et al.* 2006).

Environmental changes such as the northward advance of tree lines, combined with rapid industrial development, create challenges for traditional livelihoods such as reindeer herding.

Figure 3.7: Changes in Arctic vegetation, 1982–2005



Source: CAFF 2010

Access to many areas on land, especially in northern Canada and Russia, is becoming more difficult as ice roads melt earlier and freeze later, severely affecting communities and industrial development (AMAP 2011; Stephenson *et al.* 2011). At the same time, because the seasonal Arctic Ocean ice cover is decreasing in area, volume and duration, new economic opportunities are presenting themselves, including increased tourism, forestry, agriculture, and expanding oil, gas and mining developments. Nonetheless, some communities in the Arctic most affected by thawing permafrost and/or coastal erosion are being forced to relocate (ACIA 2005), and further research is needed to foresee how living conditions are likely to change and to evaluate possible adaptation options, taking the region's indigenous peoples into particular consideration (AMAP 2011).

At the southern pole, the landmass of Antarctica also has a profound effect on the Earth's climate and ocean systems. However, in contrast to the Arctic, the Antarctic land mass is 99 per cent covered by glacial ice. The changes occurring in this region are discussed in greater detail in Chapters 4 and 7.

Urban areas and human infrastructure

Urbanization has progressed at an extraordinary rate in recent decades and this growth is projected to continue throughout the century. Urban areas are the hubs of social processes, driving many changes through material demands that affect land use and cover, biodiversity and water resources, locally to globally. Nevertheless, if well planned, urban areas can reduce the overall pressure on land resources of a growing population.

Satellite-based studies calculate urban land cover at less than 1 per cent of the planet's total land surface (Schneider *et al.* 2009). However, the impact of urban areas on the global environment cannot be measured only by their physical expansion. Some studies estimate that 60–70 per cent of total anthropogenic greenhouse gas emissions are directly or indirectly related to urban areas, with a few wealthy cities contributing the majority of emissions (Dodman 2009). It is the concentration of population, economic activities and wealth generation in urban areas that drives their impact on the global environment, with demands for food, energy, water and production materials that have significant consequences for land-use change around the world (Grimm *et al.* 2008).

Most of the understanding of urbanization as a land-change process is based on individual case studies (Seto *et al.* 2010) that reveal significant differences in urbanization processes between regions and countries, and even within countries. Ecological footprint analyses of cities provide a symbolic parameter illustrating the impacts of those differences on the local and global environment. For example, the inhabitants of a typical city of 650 000 inhabitants in the United States collectively require 3 million hectares of land to meet their domestic needs, while those of a similar-sized city in India require just 280 000 hectares (Newman 2006).

Urban trends

The UN Population Division projects that between 2007 and 2050, the world's urban population will increase by more than 3 billion, with almost all future population growth expected to take place in the cities and towns of developing countries (Montgomery 2008). By 2050, more than 70 per cent of China's population and 50 per cent of India's is likely to be urban, with China expected to have 30 additional cities of more than 1 million inhabitants and India 26 (Seto *et al.* 2010).

Urbanization is not a homogeneous process (Seto *et al.* 2010). Recent studies suggest a significant increase in land requirements for urban uses in the next 40 years – potentially an additional 100–200 million hectares (Bettencourt *et al.* 2007) (Figure 3.8). This increase is expected to occur primarily in sprawled patterns and to have major effects on greenhouse gas emissions, air pollution and waste management (Lobo *et al.* 2009).

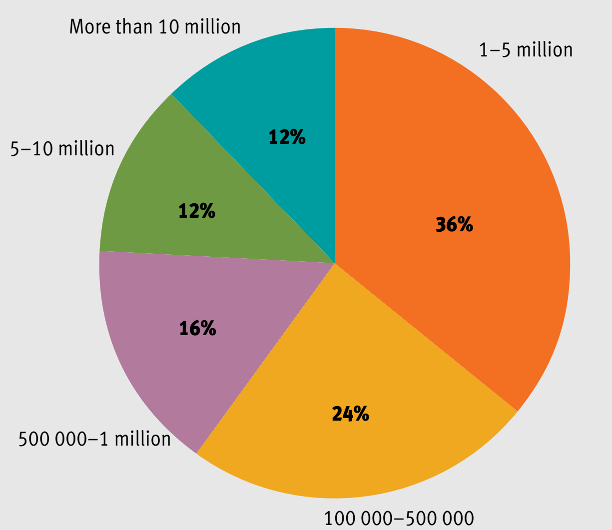
Very large cities exert local and global impacts on the environment, for example the emission of greenhouse gases or aerosols that have a dimming effect in the atmosphere. Small and medium cities, despite their own environmental impacts, may have better opportunities to improve their relationship with the environment and social well-being, particularly in low-income and middle-income countries, where population will concentrate in the future (Seto *et al.* 2010, Martine *et al.* 2008). Only 12 per cent of the total urban population in developing countries lives in very large urban areas of more than 10 million people, while 40 per cent lives in cities of less than 1 million (Figure 3.9) (Montgomery 2008).

Figure 3.8 Urban expansion in the Pearl River Delta, China, 1990–2009

The upper delta area shown in the left-hand image had over 7 million people in 1990, but has since more than tripled to over 25 million, with the cities of Dongguan, Foshan, Guangzhou and Shenzhen beginning to merge into one continuous city. This intense urbanization has led to the loss of productive farmland and natural areas, as well as creating a variety of environmental problems.

USGS EROS Data Center 2010 and UNEP 2011c

Figure 3.9 Distribution of the urban population of developing countries, by city size



Source: Montgomery 2008

MAJOR ISSUES IN LAND CHANGE

The changes in land use presented in this chapter are a product of complex interactions between human actions and biophysical processes. International goals provide one set of guidelines for land management, but these are often overshadowed by other pressures and competing demands. Here, four major themes are explored that help to explain the apparent movement away from achieving land-related goals:

- economic growth at the expense of natural capital;
- competing demands for land;
- increased separation of production from consumption; and
- governance challenges related to sustainable land management.

Each is illustrated with examples of impacts on land resulting from these pressures, as well as opportunities to move land management decisions towards social and ecological outcomes in line with international goals.

Economic growth and natural capital

The global economic system is based on the pursuit of perpetual and unsustainable growth. Distorted incentives have reduced natural capital, while often rendering attempts to curtail resource or energy use politically problematic (Chapter 1) (Daly and Farley 2010; Dasgupta 2009). Simply put, economic growth has come at the expense of natural capital.

Today, many terrestrial ecosystems exhibit degradation and reduced resilience. This can be linked to the failure to account for the vital functions of these ecosystems in economic cost-benefit analyses. For example, financial pressures have encouraged the irrigation and subsequent salinization of vast dryland areas, making them very difficult to rehabilitate (Sakadevan and Nguyen 2010). Wetlands continue to be drained for agriculture and urban development, destroying their ability to regulate water quantity and quality and buffer against extreme weather events (Box 3.3). Deforestation and forest degradation produce financially attractive short-term returns, but global natural capital losses have been recently estimated at between US$2 trillion and US$ 4.5 trillion each year (Kumar 2010).

Ecosystems have priceless spiritual, aesthetic and cultural dimensions. They are also the cornerstones of economies, but their real value remains effectively invisible in national profit and loss accounts (TEEB 2010). Allowing the privatization of profits from the extraction of natural capital at the expense of more innovative and equitable land management approaches is a pervasive problem across all land covers and uses. Incentives that are narrowly focused on economic growth often encourage land management that degrades ecosystem services,

Box 3.3 Restoring wetlands along the Mississippi

Wetlands can help control floods by absorbing and storing high levels of precipitation. However, the Mississippi River basin in the United States has historically been managed by draining wetlands for agriculture and building dams and levees to contain floodwaters, a strategy that has worsened the impacts of flood events (Hey and Philippi 1995). The coastal wetlands of the Mississippi Delta have likewise been replaced with artificial flood control structures, compromising ecosystem services such as soil formation, provision of habitat for fish and crustaceans, and protection against severe storms (Twilley and Rivera-Monroy 2009).

In 2005, Hurricanes Katrina and Rita brought into focus the importance of maintaining wetlands as buffers against natural hazards. The State of Louisiana has since assigned 37 per cent of revenues from new oil and gas projects to coastal protection and restoration; combined with other funds, this could provide up to US$1 billion per year over the next 30 years (Day *et al.* 2007). Research suggests that an investment of US$10–15 billion in restoring the Mississippi Delta could generate the equivalent of US$62 billion by avoiding losses from storm damage and reduced ecosystem functions while gaining additional ecological benefits (Batker *et al.* 2010).

Box 3.4 The Mau Forests complex, Kenya

The Mau Forests complex in Kenya provides goods and services worth US$1.5 billion a year through water for hydroelectricity, agriculture, tourism and urban and industrial use, as well as erosion control and carbon sequestration (TEEB 2010). Alternative accounting has helped spur the government of Kenya to invest in rehabilitating the area and its vital ecological services, though challenges remain in addressing the interests of people living there (UNEP 2011a).

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while including and valuing ecosystem services in accounting systems can help protect and enhance them. Successful strategies rest on improving understanding of ecosystem functions and building that understanding into policies and institutions (Daily *et al.* 2009). Indeed, recognition of the multiple uses and multiple values of ecosystems can be used to leverage resources for their protection (Boxes 3.3 and 3.4).

Over the past two decades, payment for ecosystem services (PES) has gained attention as a mechanism with the potential to account for services provided by ecosystems in market transactions, build bridges and balance interests between the users and providers of these services, and deal with the linked challenges of conservation and poverty alleviation (Pascual and Corbera 2011; Engel *et al.* 2008). Payment for ecosystem services involves a suite of approaches linked to a broad central idea: "the transfer of resources among social actors with the objective of creating incentives to align individual and/or collective land-use decisions with the social interest in the management of natural resources" (Muradian *et al.* 2010).

The concept of PES offers several advantages over conventional conservation approaches: it complements command-and-control and polluter-pays principles with more flexible, incentive-based approaches; it is conditional and voluntary, with the potential to promote equity, accountability and cost effectiveness; and it can produce co-benefits for livelihoods and contribute to poverty alleviation (Borner *et al.* 2010; van Hecken and Bastiansen 2010). Positive land-use outcomes have been achieved through some PES initiatives in, for example, Colombia, Costa Rica and Nicaragua, where tree cover has increased and degraded pasture decreased due to a regionally integrated PES project (Chapter 12).

However, groups who oppose the idea of nature being commoditized or traded have criticized the concept (Pascual and Corbera 2011; Corbera *et al.* 2007). Furthermore, despite promising initial benefits such as increased land-tenure security, current evidence of PES's cost effectiveness and the conditions under which it has positive environmental and socio-economic impacts remains inconclusive, particularly in developing countries with weak governance (Pattanayak *et al.* 2010; Wunder *et al.* 2008).

Challenges ahead for PES focus on cost effectiveness, monitoring capacity, enforcement, transparency and accountability, and clear boundaries to land access and tenure rights (Borner *et al.* 2010). Taking into account social norms and culture, building trust between actors and dealing with power relations will ultimately define benefit allocation strategies and successful long-term implementation of PES (Bille 2010; van Hecken *et al.* 2010).

Competing demands for land

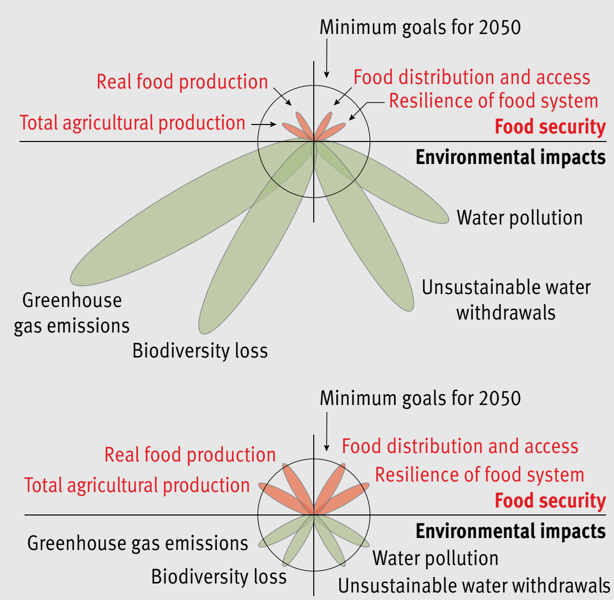
The challenge of feeding a growing human population has been compounded by rising affluence in some regions. Changing diets and increasing demand for biofuels and other industrial materials such as timber have intensified competition for land and pressures on terrestrial ecosystems.

Food security

To meet the Millennium Development Goal (MDG) 1c on reducing hunger, global food production will have to increase and food distribution improve. To meet MDG 7 and other environmental goals, agriculture needs to reduce its current environmental impacts (Figure 3.10).

Although estimates vary, the Food and Agriculture Organization of the United Nations (FAO) projects that to reduce the proportion of developing countries' populations that are chronically undernourished to 4 per cent in the year 2050, world food production will need to increase by 70 per cent from 2005 levels (Bruinsma 2009). Although food consumption per person is increasing across all regions, it is unevenly distributed and the number of malnourished people continues to rise as more grain is diverted to produce meat for those who can afford it. Livestock and poultry can serve as an important source of protein in areas of chronic food insecurity and provide an important buffer in times of crop failure, but a disproportionate share of agricultural land is dedicated to meat and dairy production for consumption in developed countries. Such land use is less efficient in meeting global food needs and comes with greater environmental consequences than cropland (Steinfeld *et al.* 2006). For

Figure 3.10 Food security and environmental goals for agriculture by 2050



Each lobe represents the status of a particular theme, with the circle defining the balance required to meet the goals. The upper figure shows the current situation, reflecting a shortfall on food security goals and excessive environmental impacts; the lower figure shows a hypothetical situation in which all goals for 2050 are achieved.

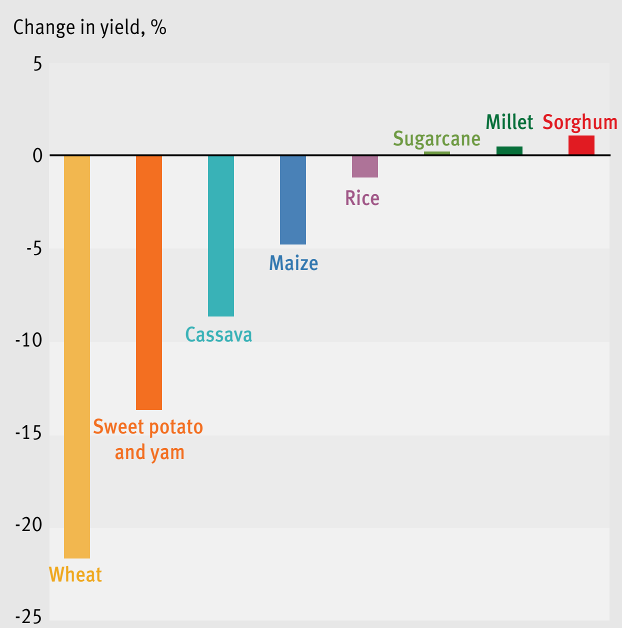
Source: Adapted from Foley *et al.* 2011 example, it is estimated that the amount of grain fed to livestock in the United States is more than seven times that consumed directly by the population (Pimentel and Pimentel 2003).

Meanwhile, about one-third of all food that is produced for human consumption is wasted or lost – approximately 1 300 million tonnes annually (Toulmin *et al.* 2011). The concept of food security moves beyond the question of whether adequate food is available and considers whether people have physical and economic access to food (FAO 2008). This draws attention to a broad set of social and political issues related to food distribution.

It will be challenging to meet future global demand for food while avoiding, or at least mitigating, negative impacts on forests, wetlands and other ecosystems – and at the same time reducing poverty, supporting livelihoods, and ensuring food safety and animal welfare. There is little debate that more land will have to be allocated to agriculture, but this will not be sufficient without increasing yields and reducing losses along the food supply chain. Climate change is likely to complicate matters further by affecting crop yields in many areas (Figure 3.11) (Ringler *et al.* 2010; Lobell *et al.* 2008).

A variety of agricultural approaches is likely to provide the best outcomes for food security and environmental well-being. High-input, intensive agricultural methods undeniably increase agricultural yields, though these gains may come at the expense of long-term soil fertility (Foley *et al.* 2005). Location-specific approaches are also needed in order to achieve sustainable land use based on biophysical as well as socio-economic considerations (Chapter 12) (DeFries and Rosenzweig 2010), while agroecology and urban agriculture can contribute to the global food supply (Perfecto and Vandermeer 2010; Zezza and Tasciottia 2010). Agricultural practices that conserve soils and nutrients such as no-till farming (Chapter 12) can complement efforts to restore degraded and abandoned agricultural land.

Figure 3.11 Projected changes in sub-Saharan African crop yields due to climate change, 2050



Source: Ringler *et al.* 2010

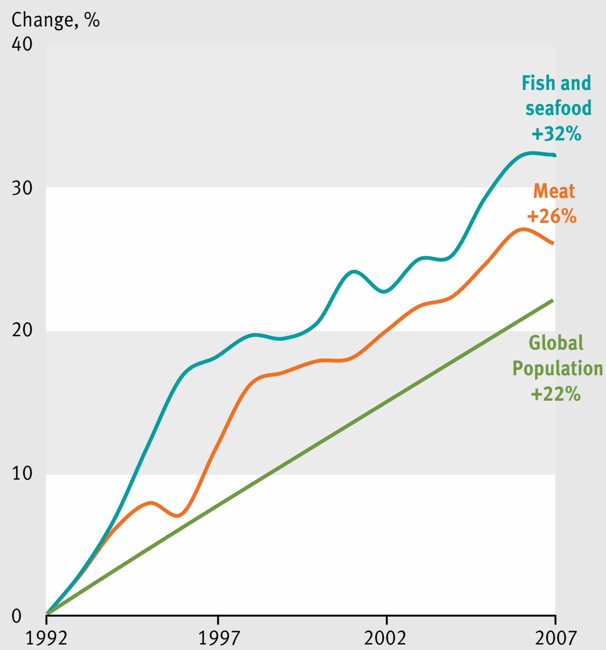
The world's food system faces increasingly complex and interconnected challenges. © *Ralf Hettler/iStock*

Meeting the global need for food will be one of the most important challenges of this century, and a portfolio of solutions including conservation agriculture, high-yielding cultivars, and efficient and carefully managed use of fertilizers is needed rather than promotion of a single strategy. Advocates of genetically modified crops point out their potential to increase yields while reducing the use of agricultural chemicals (Brookes and Barfoot 2010; Fedoroff *et al.* 2010), although resistance to their use remains, in part, due to the uncertainty of potential risks to human health and further loss of agricultural biodiversity (Chapter 5).

Meat production

Meat production has increased significantly during the past two decades, outpacing the rate of population growth over the same period (Figure 3.12). Large differences in meat consumption exist both within and between countries, ranging from an average of 83 kg per person per year in North America and Europe to 11 kg per person per year in Africa (FAO 2009). Population growth, urbanization and increasing incomes are expected to continue to raise demand for meat, particularly in developing countries (Delgado 2010).

Figure 3.12 Change in global population and in meat, fish and seafood supplies, 1992–2007



Source: UNEP 2011c

The environmental impacts of meat production depend on intensity, extent and management. Nonetheless, growing demand for meat worldwide has been an important driver of deforestation in South America, as forest is cleared to plant soy for livestock feed (Box 3.5). As meat production has grown, so has the area harvested for soybean crops, which expanded to 98.8 million hectares in 2009 from 74.3 million hectares in 2000, and 50.4 million hectares 30 years ago (FAO 2012). An increasing demand for meat has the potential to compound rangeland degradation. Livestock production accounts for over 8 per cent of global freshwater use and is among the largest sources of water pollution leading to eutrophication, algal blooms, coral reef degradation, human health issues, antibiotic resistance and disruption of nutrient cycling (Steinfeld *et al.* 2006). Considering the entire commodity chain, including deforestation for grazing and forage production, meat production accounts for 18–25 per cent of the world's greenhouse gas emissions, which is more than global transport (UNEP 2009b; Fiala 2008; Steinfeld *et al.* 2006). Reducing meat consumption in regions where it is relatively high could thus bring a range of environmental benefits (Marlow *et al.* 2009).

Meat and dairy production systems account for a large proportion of the global land area. *© Anna Kontorov*

Biofuels

An urgent search for renewable sources of energy has resulted in policies that promote the use of biofuels. Increased production of crops that can be used for multiple purposes including food, feed or fuel – such as oil palm, soy, maize and sugar cane – is indicative of this trend (Figure 3.14). However, subsidies that promote biofuels have been linked to distortions in the world food system, leading to increases in food prices (Pimentel *et al.* 2009). Recent changes in the linked production of food, feed and fuel have far-reaching impacts for ecology as well as for social relations and vulnerability (Bernstein and Woodhouse 2010; McMichael and Scoones 2010). While no energy source is completely problem-free, biofuels present particular challenges to land use and terrestrial ecosystems. This, combined with the recent rapid increase in their production, is the reason for examining them here.

While a major motivation for promoting and investing in biofuels has been the desire to reduce greenhouse gas emissions, recent research shows that their emissions balance varies widely depending on which crops are grown, where, and which production methods are used (Cerri *et al.* 2011; Johnston *et al.* 2009; Pimentel *et al.* 2009). Biofuel crops have been linked to deforestation, for example in Indonesia (Box 3.6), and to encroachment into conservation lands. Once these land-use changes are taken into account, the biofuel carbon balance can become negative, meaning that more carbon is released producing and using biofuels than the equivalent amount of energy from fossil fuels (Melillo *et al.* 2009; Fargione *et al.* 2008; Searchinger *et al.* 2008).

Crop-use changes stemming from demand for biofuels have already been observed. For example, in 2007, the United States converted 24 per cent of its corn to ethanol, supported by government subsidies. The US Renewable Fuels Standard of 2007 mandated an increase in biofuel production from around 6.5 billion litres (1.7 billion US gallons) per year in 2001 to 136 billion litres (36 billion US gallons) per year by 2022 (US Government 2007). Also in 2007, US farmers planted the largest area in maize since 1944: 37.8 million hectares, an area 20 per cent bigger than in 2006 (Gillon 2010). This crop change, which was subsidized, resulted in calling back into production many set-aside lands in the Conservation Reserve Program (CRP) that used to help check surpluses, maintain price levels and promote an ecological balance. Between late 2007 and March 2009, the total area of CRP land in the United States dropped from 14.9 million to 13.6 million

Box 3.5 Brazil's forest policy and soy moratorium

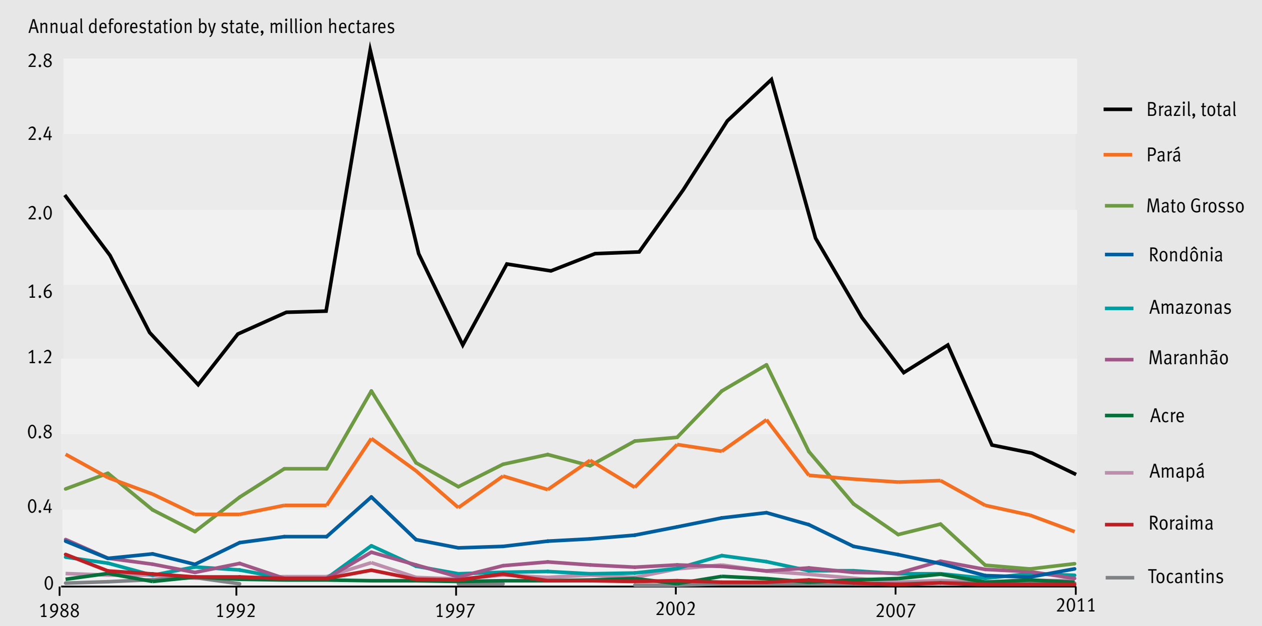
While most Amazonian deforestation is linked to cattle pasture and ranching, forest conversion for cropland – especially soy – increased in Mato Grosso during 2000–2004 (Morton *et al.* 2006), and evidence suggests that by displacing pastures, soy production may also drive deforestation (Barona *et al.* 2010). A sharp decline in annual deforestation during 2004–2009 (Figure 3.13) coincided with the introduction of new policies as part of the Action Plan for Prevention and Control of Deforestation in the Amazon (PPCDAm). These include:

- creating new protected areas in deforestation hot spots;
- establishing a deforestation monitoring programme using satellite imagery;
- an assertive law enforcement strategy allowing for property apprehension, forfeiture or even destruction;
- withholding public rural credit from producers who break environmental regulations; and
- an obligation on municipalities to reduce deforestation rates below a certain threshold and register protected areas in a GIS database to make illegal deforestation promptly apparent (BRASIL 2009).

Pressure from consumers in Europe and a Greenpeace campaign against illegal deforestation also led the Brazilian Vegetable Oil Industry Association (ABIOVE) and National Cereal Exporters' Association (ANEC) to sign an agreement in July 2006 in which members pledge not to acquire soybeans from newly deforested areas in the Amazon. The success of this moratorium has prompted efforts to persuade the beef industry to make its own commercial agreement.

Despite the apparent success of these and other policies and agreements in reducing deforestation, challenges remain. For example, many are concerned that proposed changes to Brazil's forest code may reduce forest protection (Tollefson 2011). The rise of deforestation in other biomes and countries is also a concern, which has led the Brazilian government to launch an action plan for the Cerrado biome (BRASIL 2010) and disseminate lessons learned to neighbouring Amazonian countries.

Figure 3.13 Clear-cut deforestation in the Brazilian Amazon, 1988–2011

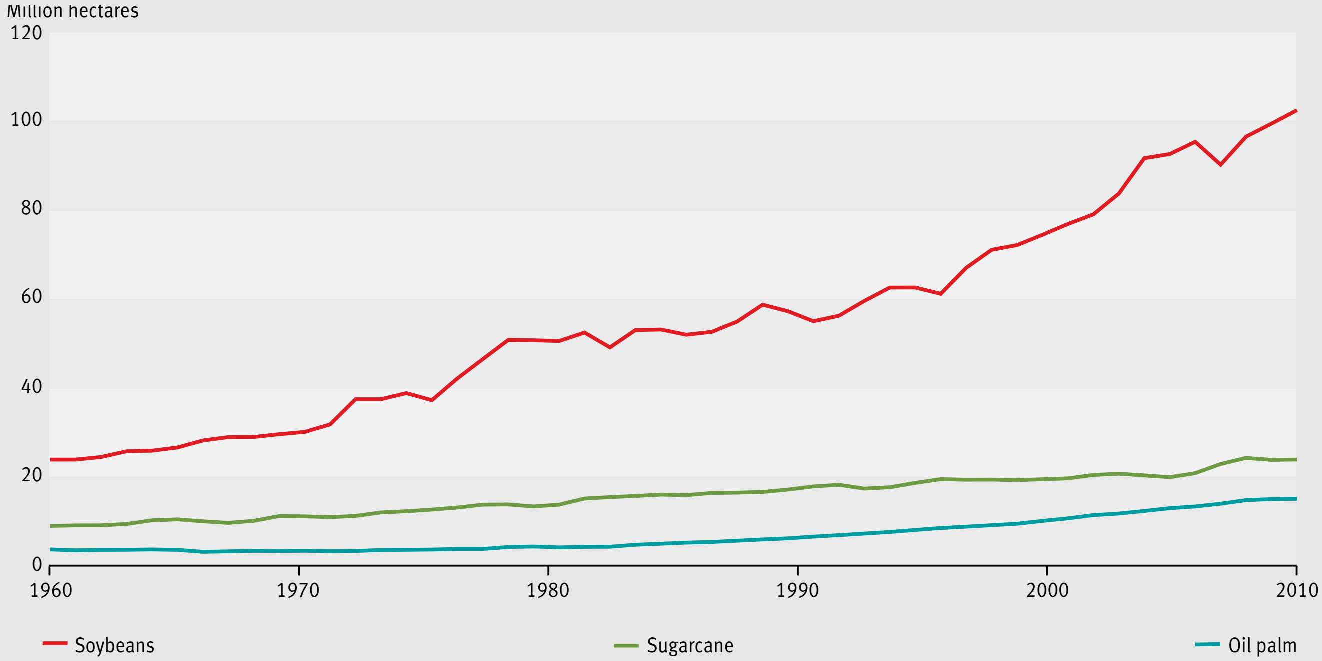


Source: INPE 2012

hectares (Gillon 2010). In other words, close to 1.3 million hectares of conservation lands were lost in just over a year.

A similar trend can be seen in the European Union (EU), particularly Germany, whose production capacity for biodiesel increased fivefold between 2004 and 2008 (Franco *et al.* 2010). Although Germany's rapeseed cultivation reached 1.53 million hectares in 2007, a little over half of which was used for fuel to meet its EU mandatory biodiesel blending target, Germany needs an additional 1.8 million hectares of rapeseed, which can be done only by increasing the conversion of permanent grassland – similar to the US CRP. However,

Figure 3.14 Area under cultivation for selected crops in humid tropical countries, 1960–2010



Source: UNEP 2011c

Germany has already used its maximum allowable 5 per cent of grassland under the EU Common Agricultural Policy (Franco *et al.* 2010). Such constraints on agricultural expansion in the United States and European Union help explain the push to outsource biofuel (and food) production to other countries.

Critiques of biofuels have been accompanied by the emergence of alternatives. For example, under certain conditions, community-based biofuel production for local consumption can be desirable, such as in Brazil where some small-scale farmers produce fuel for their own vehicles and equipment (Fernandes *et al.* 2010). To be considered beneficial, biofuel production should satisfy multiple criteria, including real energy gains, greenhouse gas reductions, preservation of biodiversity and maintenance of food security (Tilman *et al.* 2009). Indeed, the principles of ecoagriculture (Milder *et al.* 2008) can be applied to help guide biofuel production towards the mutual attainment of production, livelihood and conservation

Box 3.6 Palm oil expansion and rainforest destruction in Indonesia

The expansion of oil palm plantations, both for food and fuel, is one of the most significant causes of rainforest destruction in South East Asia, where the area under oil palm increased from 4.2 million to 7.1 million hectares between 2000 and 2009 (FAO 2012). In Indonesia, two-thirds of oil palm expansion has occurred by converting rainforest (UNEP 2009a). Clearing tropical forests produces a carbon debt that lasts from decades to centuries, contradicting one of the main reasons for pursuing biofuels in the first place (Gibbs *et al.* 2008). It also compromises vital ecosystem functions provided by rainforests that cannot be replaced by plantations.

In 2009 the Indonesian government projected a dramatic increase in the area planted to oil palm during the next one or two decades – up to 20 million hectares – mostly on cleared forest land (UNEP 2009a). This target was based on two linked assumptions:

- increasing demand in China and India for cooking oil and other consumer goods, from chocolate to shampoo, that use palm oil; and
- increasing demand for biofuels in Europe and elsewhere (McCarthy 2010; White and Dasgupta 2010).

In May 2011 the President of Indonesia signed a two-year moratorium on new permits to clear primary forests and peatlands, potentially slowing oil palm expansion; however, secondary forests and existing contracts remain exempt (USDA 2011).

Table 3.4 Timber and fibre consumption, 2002 and 2008

Type	2002 Million m³	2008 Million m³	2002–2008 % change
Fuelwood	1 795	1 867	+4
Industrial wood	1 595	1 544	-3
Wood-based panels	197	263	+34
Pulp for paper	185	191	+3
Paper and paper board	324	388	+20

Source: FAO 2011b, 2005

objectives. While such systems represent only a tiny portion of overall biofuel production, they provide an opportunity for equitably distributed alternative fuels to benefit land-based ecosystems, for example by reducing charcoal production.

Timber and wood products

Forests are the main source of timber for fuel, industry, pulp, paper and wood-based composites (Table 3.4). Key factors contributing to the rise in consumption are population and economic growth (FAO 2011). In addition, an increase in the absolute number of people living in poverty, especially in rural areas, and continued urbanization contribute to the growth in consumption of wood fuels, while enhanced economic growth in emerging economies contributes to the increase in consumption of paper and paper products.

Protected areas

Protected areas are an important mechanism for the conservation of vulnerable environmental resources, although there are controversies as to whether they sometimes come at the expense of the livelihoods of local people. Rates of deforestation are much lower within reserves than outside them (Scharlemann *et al.* 2010; Nagendra 2008), and some research cites the positive benefits that protected areas have on the conservation of ecosystem services (Stolton and Dudley 2010). But when the underlying pressures imposed by local populations are not adequately considered, substantial monitoring and enforcement are needed to enforce rules designed to sustain natural resources, and governance has been found to be most effective when local users participate in the design and implementation of natural resource governance. There is also some evidence of spill-over effects in countries that enact conservation policies, for example by increasing cereal imports from elsewhere (Rudel *et al.* 2009). Protection in a given area has also been found to contribute to deforestation on the adjacent land to which displaced human populations have moved (Wittemyer *et al.* 2008). Despite the growing area of land with protected status – currently almost 13 per cent of the planet's terrestrial area is under some degree of protection (Chapter 5) – policy makers should not rely solely on this mechanism to preserve natural resources (Ostrom and Cox 2010). Instead, they should develop capacity for adaptive management strategies that produce the best institutional fit for natural resource problems while taking into consideration the need to protect local property rights and local livelihoods.

The separation of consumption from the impacts of production

Urbanization and globalization contribute to the separation between places where resources and goods originate and where products are consumed. Recent research suggests that the spatial distance between production and consumption is both significant and growing (Erb *et al.* 2009). As a result, many of the ecological costs of consumption are borne by people and places increasingly far from consumption sites. While urbanization draws people into densely populated spaces and concentrates demand for food, materials and consumer products, globalization and trade facilitate the movement of people and goods, making both regional and international transfers of resources and finished products possible. Large-scale land acquisitions to supply food, fodder and other forest products as well as other natural resources to markets in distant countries are both a recent outcome of and a contributor to the separation of production and consumption (Toulmin *et al.* 2011). If carefully planned and managed, urbanization and globalization can present opportunities to increase efficiency of resource use.

Drivers of increased separation

Urbanization affects land use and land cover, water use and biodiversity at local and regional scales through social processes that drive consumption patterns and material demands. Higher purchasing power among many urban workers contributes to improved quality of life, but at the cost of new challenges for natural resources and environmental management. For example, Western-style diets are increasingly being adopted globally in urban areas (Pingali 2006). Similarly, improved urban lifestyles are accompanied by higher consumption of water and energy and increased carbon emissions. These urban consumption patterns intensify stresses on distant as well as local ecosystems.

Globalization is not new, but its current iteration has some distinct features (Chapter 1). Lower trade barriers, improved communication technologies and relatively cheap transport have all encouraged countries to become increasingly specialized in their economic activities and reliant on international trade to connect products and services with distant markets (Gibbon *et al.* 2008). While international trade can make use of strategic advantages to produce goods in an efficient way, it also makes it easier to externalize both environmental and social costs. The well-being of individuals in one place is often based on the degradation of the environment elsewhere, for example by non-renewable resource extraction. Meanwhile, both resources and pollution are embedded in trade (Chapter 4), and countries that place greater emphasis on free-market economic policies have been linked to higher levels of environmental degradation (Özler and Obach 2009). The challenge for the global economy

Yasuni National Park on the fringes of the Amazon Basin in Ecuador – believed to be the single most biodiverse place on the planet – has come under severe threat following the discovery of rich oil deposits beneath the park's rivers. In December 2011, US$116 million payment for ecosystem services was raised by crowd-sourcing, temporarily halting ecological devastation and the release of more than 400 million tonnes of carbon dioxide (CO_2). *© Sebastian Liste*

is to encourage the best of what it can offer in terms of efficient resource use while taking measures to reduce the occurrence, concentration and transfer of environmental and social costs.

Land deals

Recent changes in production patterns can be linked to the convergence of food, energy, environmental and financial crises, and a continuing surge in the mineral and timber industries (Tables 3.2 and 3.4; Chapter 1). These interactions have brought corporations and some national governments, based in the global North and South, to forge widespread land deals, sometimes referred to as land grabs, in distant countries. The UN Committee on Food Security suggests that such large-scale land acquisition now involves close to 100 million hectares (Toulmin *et al.* 2011). Concentrated in the global South, these land deals are intended to produce food, feed, biofuels, timber and minerals, usually for export. This ongoing global rush for land is altering land-use patterns and social relations, and involves a new combination of people and pressures. Given the rapid pace of recent developments and projected growth in demands for food, feed, biofuels and materials, it is likely to have major impacts on future land use.

The 2007–2008 food price spike inspired multi-sectoral investors to purchase or lease land for food production and export (Toulmin *et al.* 2011). At the same time, biofuel blending requirements in the EU and many other countries have provided another impetus for external land deals and land-use change. This has directly and indirectly inspired the expansion of oil palm plantations in Colombia, Guatemala, Indonesia and Malaysia, sugar cane ethanol production in Brazil and Southern Africa, soy cultivation in Argentina and Brazil, and the planting of jatropha in Ghana and India, amongst other developments (Franco *et al.* 2010). The emerging pattern of production in these newly opened sites is large-scale, industrial monoculture (Novo *et al.* 2010; Richardson 2010). Even in cases where contract growing with smallholders is promoted as a key component of new enterprises, monoculture and industrial production methods are adopted, for example in the oil palm sector in Indonesia (McCarthy 2010).

In theory the term marginal lands, often applied to land deals, refers to lands that are far from road networks, are not irrigated, and are not used for intensive commercial agriculture. However, in practice there are indications that land deals have encroached on prime agricultural lands, suggesting that investors do not want to invest in lands with little access to water sources or transport infrastructure.

Displacement of local, including indigenous, people is a potential outcome of these land deals. This becomes a problem if people have nowhere go to seek employment or construct livelihoods (Li 2011). This has happened in several sites of current land deals, pushing people to further crowd urban spaces or into more fragile environments such as remaining forest, higher slopes or river banks. For example, in the Democratic Republic of the Congo, large-scale agricultural investment has reportedly pushed local farmers into a national park (Deininger *et al.* 2011). But not all land deals have led, or will lead, to dispossession. Different outcomes of land deals for the rural poor are illustrated by McCarthy (2010) in Jambi, Indonesia, where three villages showed three broad trajectories: dispossession, relatively successful incorporation into the oil palm enclave, and adverse incorporation with precarious employment and livelihoods.

There are competing views on how to respond. One position argues that land deals offer both opportunities and threats, and that opportunities can be harnessed and threats managed by promoting a voluntary land-deal code of conduct (Deininger 2011). In contrast, proponents of minimum human rights principles argue that voluntary codes may be insufficient to ensure that agricultural investment "benefits the poor in the South, rather than leading to a transfer of resources to the rich in the North" (De Schutter 2011). An in-between position is reflected in the Voluntary Guidelines for the Democratic Governance of Natural Resources promoted by FAO, which, unlike corporate-led codes of conduct, bind member states to mandatory reporting. How these viewpoints unfold remains to be seen.

Land governance

Many of the challenges for sustainable land management stem from underlying weaknesses in land governance systems. Generally, there are three components of a governance system: actors and organizations, institutions, and practices (GFI 2009). Incompatibility between these is one of the most common reasons for the lack of successful transition from resource-extractive to sustainable management of land resources. For example, various countries have redirected their policies and management rules towards sustainable forest management, but due to structural and cultural resistance in forestry organizations, management practices have not changed to the expected level (Kumar and Kant 2005). Other common features of poor land governance are low levels of transparency, accountability and participation in decision making, and a lack of capacity amongst the actors and organizations responsible for land management.

Land governance includes structures ranging from totally centralized to completely decentralized. A major challenge is to find the best governance system, which depends on existing governance alongside the social, economic and environmental conditions and their dynamics (Kant 2000).

Market-based approaches

Heightened interest in carbon sequestration has inspired new incentives and financing for ecosystem protection. Local and global initiatives have started to invest in market-based climate approaches that attach a financial value to the carbon stored in forests, offering incentives for developing countries to invest in low-carbon development. One such opportunity – Reducing Emissions from Deforestation and Forest Degradation (REDD) in developing countries – has emerged as an important component of a global strategy to reduce emissions while generating financial flows from North to South (Scharlemann *et al.* 2010; Angelsen 2009). Since its inception, REDD has evolved into REDD+, which now goes beyond deforestation and forest degradation to include conservation, sustainable forest management and enhancement of forest carbon stocks. Evidence of the potential for carbon sequestration in drylands and grasslands is accumulating in support of REDD+ programmes for these ecosystems as well as forests (Neely *et al.* 2009).

At this stage, REDD+ has not been incorporated into any formal international carbon market, but it is likely to form a key element of a post-Kyoto climate change treaty by promoting the avoidance of deforestation and allied measures as eligible activities for countries seeking to meet their obligations. Carbon offset payments would encourage developing countries to reduce national deforestation rates, while REDD+ could include incentives to promote afforestation, reforestation and improved forest management. Research suggests that when appropriate techniques are used, forest restoration is a cost-effective means of sequestering carbon while providing abundant social and ecological benefits (Sasaki *et al.* 2011).

Proponents from both science and policy believe that REDD+ will not just conserve forests; they also consider it one of the most cost-effective carbon abatement options worldwide (Corbera *et al.* 2010; Dickson and Osti 2010; Sikor *et al.* 2010; UN-REDD 2010; Kindermann *et al.* 2008; Thoms 2008). With the right safeguards in place, REDD+ could offer crucial new incentives for achieving sustainable development goals – which have proved elusive since the 1992 Rio Earth Summit – by simultaneously enabling biodiversity conservation, watershed protection, capacity building in tropical forest nations and poverty alleviation for rural communities (Sikor *et al.* 2010).

Much of the debate around REDD+ has focused on its international aspects. However, its success will largely depend on allocating benefits at the local to national levels and creating domestic safeguards to prevent perverse incentives and the marginalization of forest-dependent communities (Phelps *et al.* 2010; Cotula and Mayers 2009; Daniel and Mittal 2009). To this end, some stakeholders are concerned that REDD+ could pose new risks to already vulnerable populations through restricted access to land, tenure insecurity, conflict over resources, centralization of power, and distortion effects in local economic systems. These observers caution that REDD+ will only achieve lasting results if it is suitable for adaptation to the particular circumstances of relevant countries and can meet the needs of local people while building their capacity (IUCN 2010/11; Mayers *et al.* 2010; Preskett *et al.* 2008).

The risks and opportunities for REDD+ will depend on several factors, including how it will be financed and implemented. Many challenges are shared by forest countries, but responses and solutions will often have to be developed according to country-specific and local characteristics. Ultimately, if REDD+ is to be successful, it must generate substantial revenues to implement conservation and sustainable forest management while supporting rural poverty reduction and livelihoods. At the same time, it must recognize the dynamic complexity of global systems, where cause and effect are often distant in time and space.

Land management and decentralization

Governance plays a major role in how land resources are monitored and used and how environmental protection is enforced. Proponents of decentralized natural resource management suggest that giving local-level officials greater responsibilities should result in more efficient, flexible, equitable, accountable and participatory governance (Blair 2000). Local-level decision makers often know more about local conditions and are therefore well positioned to develop new management solutions. This is important from the perspective of adaptive management and providing decision makers with the flexibility to quickly develop solutions to unforeseen problems (Ostrom 2007). But decentralization is only effective if local governments have the financial resources and technical capacity to monitor environmental change (Andersson 2004). Positive outcomes from decentralized environmental governance are also unlikely in the absence of public participation in local government decision making (Larson 2002; Blair 2000); this emphasizes the importance of developing the capacity of local-level stakeholders in the sustainable management of land systems.

Capacity building for sustainable land management

Capacity building recognizes the knowledge systems, perspectives and values of all stakeholders and uses an in-depth understanding of how a resource system functions. As sustainable land management requires a different set of organizational, technical, economic, environmental and managerial skills from that of many land managers, building the capacity of all actors and organizations can be central to its successful integration.

Box 3.7 Sustainable dryland management

Promising management strategies for dryland ecosystems across the world include afforestation to counteract chronic carbon loss due to land degradation, with successful examples in Israel (Tal and Gordon 2010), Iran (Amiraslani and Dragovich 2011) and eastern Uganda (Buyinza *et al.* 2010). Other progressive strategies for adaptively managing drylands include planting resilient nitrogen-fixing crops (Saxena *et al.* 2010), dune stabilization measures, run-off control, improved range management and integrated land management, for example Iran's National Plan to Combat Desertification. Programmes that build community resilience through watershed restoration in drylands, such as the Watershed Organization Trusts in India, are also promising, as are models of polycentric adaptive governance increasingly adopted in Australia (Marshall and Smith 2010; Smith *et al.* 2010). Enhanced monitoring programmes based on vegetation indices and real-time climatic data are also important in allowing for early-warning and management interventions (Veron and Paruelo 2010).

Land degradation in dryland ecosystems provides an example where the lack of capacity – scientific, technical and collaborative – limits success in addressing environmental problems. Degradation in dryland systems is driven by multiple causes and characterized by complex feedbacks that are made worse by global climate change (Ravi *et al.* 2010; Verstraete *et al.* 2009). Despite concerted efforts and a wide array of initiatives (Box 3.7), drylands continue to be threatened because of lack of agreement on the underlying driving mechanisms, characteristics and consequences of degradation (Reynolds *et al.* 2007). Long-term harmonized data are necessary not only to understand the root causes of observed changes, but also to forecast and disentangle those, possibly irrevocable, impacts of global change from the often more temporary or local variability induced by other human activity. These data gaps, and the subsequent lack of capacity and common strategies among dryland nations, can severely hamper progress towards internationally agreed goals on dryland conservation and rehabilitation.

OUTLOOK

Complex forces are affecting land resources, some at dramatic rates of change and with diverse regional and national characteristics. Certainly some land conversion trends are on an unsustainable trajectory, as global population growth and rising consumption exert ever greater pressures on land. Continued deforestation, wetland conversion and dryland degradation are of particular concern. An increasing portion of the pressure on tropical forests is shifting from the activities of small household farms to large industrial plantations producing soy, meat and dairy products, palm oil, sugar cane and other products destined for global markets (DeFries *et al.* 2010, 2008). Land degradation continues to hamper soil productivity and ecological functions in many regions. At the same time, there is significant potential to reduce greenhouse gas emissions from agricultural production (Smith *et al.* 2007). Two phenomena that have arisen since *GEO-4* are the expansion of biofuel production and a growing number of land deals in developing countries. These and other processes are unfolding rapidly. While their longer-term implications remain uncertain, early evidence of their social and environmental consequences should be closely considered. In combination, these processes are seriously affecting the environment in several regions and require urgent attention.

Data and monitoring gaps

One key to avoiding environmental damage is to effectively monitor environmental trends, yet major data gaps limit the ability to avert unwanted outcomes. Global data on land degradation have not been updated for a long time, although new estimates using satellite material are being developed. Datasets exist for land cover but do not always adequately represent areas that have experienced selective cutting or other types of modification. Forest cover losses in boreal and temperate forests are not as well studied as those in tropical forests, while evidence is still emerging of the significant carbon sequestration potential of rangelands and grasslands. Records of ecosystem change are improving, mainly through remote sensing, but reliable data on land-use change are still fragmented and often not comparable – the extent of drylands, for example, is uncertain because of the classifications and methodologies used by different programmes. Similarly, there are discrepancies between a number of wetland inventories (Ramsar Convention Secretariat 2007) and there is no comprehensive global wetlands database.

Satellite remote sensing is an essential tool for monitoring global land resources, but no such technology exists for population patterns. National census efforts, the best current technique, are sporadic and underfunded in many countries, and there is a significant data gap for population changes in rural areas. Further, it is critical to track the consequences for the environment of rapid and extensive urbanization, with its uncertain implications for land resources.

Data on biofuels – including the extent of production and use – are incomplete at the global level, although national datasets can be found for some countries. Similarly, there is a need for improved national and global monitoring of land transactions including large-scale land deals. There are also few standard indicators that governments can use to monitor the environmental impacts of different patterns of land tenure. Finally, standard methodologies for the badly needed valuation of ecosystem services are at an early stage of development.

Goal gaps

Table 3.5 summarizes progress toward the themes expressed in internationally agreed goals on land use and conservation. However, some important topics are not reflected in them. For example, there are no goals or targets that reflect the vulnerabilities and challenges specific to the polar regions.

Table 3.5 Progress towards goals (see Table 3.1)

A: Significant progress B: Some progress	C: Very little to no progress D: Deteriorating	X: Too soon to assess progress ?: Insufficient data

Key issues and goals	State and trends		Outlook	Gaps
1. Promote food security				
Reduce proportion of people who suffer from hunger	B	Proportion of malnourished people decreasing, but absolute number increasing	Depends on up-coming policy decisions and interventions	See following entries on increasing food production and access
Improve household economic access to food	C	Food per person is increasing overall, but a large gap remains between and within regions, particularly for rural poor households who now spend more than half of their income on food; one-third of food produced for human consumption is lost or wasted; land and food price volatility is influenced by rising demands for biofuels, among other economic forces	Drivers remain in place for land and food price volatility to continue; without interventions, the gap in food per person is likely to persist	Interventions to reduce post-harvest food waste; stimulate smallholder farmer-centred agricultural growth – promoting affordable access to land, water and tenure rights for poor households; coordinate domestic and regional biofuel policies to avoid worsening global food insecurity
Increase food production	C	Agricultural yields are generally increasing but a large gap remains between regions	Yields are unlikely to improve much more in developed countries; with efforts focusing on decreasing the yield gap in developing countries, much depends on how this is accomplished	Location-specific approaches to increase yields and achieve sustainable land use, for example smallholder farmer-centred agricultural growth; increased nutrient-use efficiency; improved temporal and spatial matching of nutrient supply with plant demand
2. Reverse loss of environmental resources				
Reduce deforestation rate and increase forest coverage	B	Slight slowing of deforestation but rate is still high; deforestation is concentrated in the tropics; temperate areas are experiencing some forest regrowth	Demand for timber and fibre is likely to rise; clearing for agricultural expansion, including biofuels, is likely to continue without a change in policies	Improved understanding of forest degradation; regional policy coordination to avoid leakage shifting deforestation from regulated to unregulated areas
Halt the destruction of tropical forests	B	Deforestation rate has slowed in some tropical countries, but net forest loss in Latin America and the Caribbean and Africa remains close to 7 million hectares per year	The area under the REDD+ programme and schemes for payment for ecosystem services is likely to increase, providing new incentives to protect tropical forests and their ecosystem services	Data and monitoring on carbon stocks/flux; number and area of community-managed REDD+ areas; national adaptation strategies with ecosystem-based components
Stem the loss of wetlands	C/D	Continued conversion of wetlands for agriculture, aquaculture and human infrastructure	Pressure on wetlands is likely to continue or increase as demand for agricultural land and urban expansion continues	Improved inventory and monitoring of global wetlands; renewed commitment to the Ramsar Convention at the national level
Combat desertification and mitigate the effects of drought	C	Net primary productivity is decreasing in drylands	Pressure on drylands is likely to continue	Improved inventory and monitoring of global drylands
3. Practise integrated land-use planning and management				
Integrate principles of sustainable development into country policies and programmes	B	Good progress in countries affected by the UNCCD in establishing mechanisms to ensure synergy between conventions on desertification, biodiversity and climate change, but few countries have integrated investment frameworks	Depends on upcoming policy decisions and interventions	Greater integration/collaboration between sectors
Recognize, maintain and develop the multiple benefits of ecosystem services, for example for biodiversity, and for their cultural, scientific, and recreational value in addition to their economic value	C	Some examples of valuing multiple benefits of ecosystem services, but overall still largely externalized	Depends on upcoming policy decisions and interventions	Improved non-market valuation techniques; capacity building to include multiple and local values in land-use decision making

Coon Creek Watershed in southwest Wisconsin, once one of the most heavily eroded regions in the United States, is now an impressive and integrated farmland mosaic thanks to advances in soil and farmland restoration. *© Jim Richardson*

Issues of capacity building and stakeholder participation are also inadequately represented in international goals. Several of the land-related goals that do exist lack quantifiable targets, complicating the task of assessing progress towards their achievement. A particular challenge is to acknowledge the interactions between different components of social-ecological systems at different scales.

Goals cannot be considered in isolation. Due to tensions and synergies, progress towards one goal must be viewed in light of implications for others. For example, Figure 3.10 highlights friction between MDG 1 on reducing hunger and MDG 7 on environmental sustainability: if food production is increased through agricultural expansion, it directly compromises the protection of forests, wetlands and other ecosystems. Meanwhile, efforts to address the education and health issues expressed in MDGs 2–6 can indirectly help achieve MDGs 1 and 7 in the long term. Thus, an integrated perspective on goal achievement is crucial.

Discussion of key issues

Economic growth and land resources

The global economy has quadrupled during the last 25 years (IMF 2006), but 60 per cent of the world's major ecosystem goods and services underpinning livelihoods have been degraded or used unsustainably (MA 2005a). This means that traditional economic growth cannot be the foundation of sustainable development. A new paradigm of economic welfare is required – one that is focused on improving human welfare and social equity, and reducing environmental risks and ecological scarcities. One such approach, the green economy proposed by UNEP in 2010, includes:

- valuation of natural resources and environmental assets;
- pricing policies and regulatory mechanisms that translate these values into market and non-market incentives; and
- measures of economic welfare that are responsive to the use, degradation and loss of ecosystem goods and services (UNEP 2011b).

The transition from traditional economic growth to the green economy will require changes to national regulations, policies, subsidies, incentives and accounting systems, as well as to global legal and market infrastructures, an appropriate international trade structure and targeted development aid.

Meeting the growing demand for food

Both global population and per-person consumption continue to grow. The achievement of MDG 1, the eradication of extreme hunger and poverty, will require getting more food to more people. How this is accomplished will have important implications for MDG 7 – environmental sustainability. Population growth is an important part of this complex interaction, but changing lifestyles and consumption patterns, particularly the increasing global demand for animal products, are also significant. Friction between these two MDG goals could be reduced by:

- improving efficiency along the whole food chain by increasing crop yields through research and extension, and reducing food waste and spoilage by improving transport, storage and distribution infrastructure in developing countries and changing behaviour in wealthier societies, where much food waste occurs in food retail markets and homes;
- implementing full-cost accounting for food products that reflects the environmental and social costs of their production in order to facilitate a shift in consumption patterns;
- encouraging, where appropriate, innovative approaches to food production to shorten food supply chains and enhance food security;
- evaluating the ecosystem service and carbon balance implications of potential biofuel production to inform land-use planning and management, and reducing competition between food and biofuel production, particularly in areas with the highest crop production potential.

Growing demand for non-food resources

Crop- and plantation-based biofuel production has increased rapidly in recent years and the land-use transitions associated with this could have strong environmental and social impacts. Fuel-blending targets in numerous countries mandate the continued expansion of biofuel production. Next-generation biofuels – from, for example, algae or cellulose – are still under development and are not likely to contribute a significant share of biofuel production in the near future. Governments should recognize that targets for biofuel production have both direct and indirect implications for land use at national and global scales.

Large-scale land acquisitions are growing with potentially major impacts on land-use change and social relations. Recent reports have advocated the establishment of an observatory of land tenure and rights to food to monitor access to land and ensure that land investments result in decreased hunger and poverty in host communities and countries (Toulmin *et al.* 2011). United Nations organizations could play an important role in creating precedents that could help improve food access in developing countries.

Complexity and policy challenges

An important step towards addressing these challenges is to monitor, study and understand how social and biophysical drivers interact, and the diversity of social, economic and environmental consequences they generate at local, regional and global levels. A concerted effort by international organizations, the scientific community, and national and local institutions could create the comprehensive monitoring network needed to achieve this goal – but to be effective there needs to be strong coordination between these actors.

Limitations in the assessment of land-change processes cannot and should not delay action to address their driving forces, with the precautionary principle being applied to reduce their negative impacts. Current evidence of their consequences highlights the need to act in the short term to avoid potentially irreversible negative outcomes in the long term. There are no easy answers to these complex problems, and single and isolated actions might achieve only limited positive outcomes rather than broad solutions. New governance approaches to land management could help incorporate adaptive management, capacity building and more efficient valuation of ecosystem services and natural resources by combining market-based tools with a bigger role for community agency and bottom-up approaches. New governance approaches could also help foster the changes in consumption patterns needed to reduce pressure on land systems and create better knowledge and awareness of the multiple values of ecosystems. While the leadership of UN organizations and other international institutions is a central element in these efforts, governments have a crucial role, responsibility and opportunity to act as agents of change.

New governance approaches could foster the changes in consumption patterns needed to reduce pressure on land systems and create better knowledge and awareness of the multiple values of ecosystems.

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