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Chapter 8

Land and Soil

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Executive summary

Land resources are essential for achieving 10 of the 17 Sustainable Development Goals (SDGs). Agricultural and food production are still responsible for most of the changes of land, including forests and other types of ecosystems, while human-induced land degradation remains a fundamental environmental problem affecting food security, livelihoods and lives of the people on this planet. Globalization, population growth, urbanization and shifting dietary preferences are responsible for some of the changes in our food system over the past 50 years and have increased food imports and teleconnections. There is also a growing concern over land grabbing and speculation throughout the world. Clear property rights and land-resource stewardship are crucial for ensuring sustainable production of food while preserving the ability of land ecosystems to continue providing a wide variety of other benefits to people (e.g. hydrological regulation, pollination). Rural inhabitants play a fundamental role in land conservation. The main findings regarding land can be summarized as follows.

Current trends, based on technological optimism, improved seeds, machinery and fertilizers, are not likely to supply future demands for food, energy, timber and other ecosystem services and values taking into consideration even moderate projections for land-resource availability (*well established*). By 2050, the world needs to produce at least 50 per cent more food to feed the projected global population of 10 billion people. Current land management cannot achieve this while preserving ecosystem services, the loss of natural capital, combating climate change, addressing energy and water security, and promoting gender and social equality. {8.5.1}

Food production is the largest anthropogenic use of land, accounting for 50 per cent of habitable land (*well established*). Livestock production uses 77 per cent of agricultural land for feed production, pasture and grazing land. The livestock sector provides only 17 per cent of dietary energy and 33 per cent of dietary protein demands. Therefore, using about 80 per cent of agricultural land for livestock is inefficient. {8.4.1}

The expansion of agricultural area has been slowed by increasing productivity (*established but incomplete*). Although there are regional variations, globally, the harvested crop area increased by 23 per cent between 1984 and 2015, while global crop production rose by 87 per cent. On average, per capita daily food supply in the world increased 10 per cent between 1993 and 2013. However, monocultural farming systems, sometimes assumed to be more productive and profitable, are often associated with environmental degradation and biodiversity loss. Grasslands in southern South America have been converted into soybean fields mostly for export. The expansion of oil palm in South-East Asia has been at the expense of forests and peatlands. {8.4.1}

Global food supply has become dependent on the growing trade of a small number of crops grown in a few regions with increasing crop specialization (*well established*). The share of production traded internationally in 2014 was 24, 11 and 60 per cent of global wheat, maize and soybean production, respectively. This leads to lower food prices and food-deficit countries benefit from these food imports. However, the geographic concentration of production increases systemic risk, as illustrated by recent spikes in international commodity prices due to poor harvests in certain regions. Furthermore, the growing prevalence of certain crops in global food supplies has contributed to the increasing consumption of nutritionally poor, highly processed foods, with potentially serious consequences for population health. {8.5.1}

The linkages between different places (teleconnections) are strengthening worldwide (*well established*). Demand in some places generates land transformations in others. The distance between producers and consumers may obscure ecosystem degradation in production areas. For example, demand for land resources in many urban areas is affecting land use in rural and other urban areas, both within national boundaries and internationally. {8.3.2}

Approximately one-third of food produced globally for human consumption is lost or wasted (*well established*). Approximately 56 per cent of total food loss and food waste occurs in industrialized countries, while 44 per cent originates from developing countries. {8.5.1}

Deforestation rates differ among regions, and while the global trend is continuing forest loss, many regions, especially in more developed countries, are showing an increase in forest cover (mostly in plantations) (*well established*). In the 1990s, about 10.6 million ha of natural forests were lost per year. For the period 2010-2015, this rate had dropped to 6.5 million ha/year. Simultaneously, the growth rate of planted forests is about 3.2 million ha/year, and by 2015 they accounted for 7 per cent of the global forest area mostly concentrated in high-income countries. Plantations do not provide the same diversity of ecosystem services as natural forests. {8.4.1}

Although built-up areas represent only a relatively small fraction of land, their impacts extend beyond built areas (*well established*). Since 1975 urban settlements have grown approximately 2.5 times, accounting for 7.6 per cent of the global land area in 2015. Cities and infrastructure expand differently across regions. By covering the ground with impervious surfaces, cities affect the hydrological cycle and soil function, as well as generating urban heat islands. About 3 billion urban dwellers lack access to adequate waste disposal facilities, which poses health risks (infections, exposure to chemicals, dust, others) and generates environmental impacts (soil and water pollution, greenhouse gas [GHG] emissions, others) and land-use competition. {8.4.1; 8.5.2}

Land is the most important asset for people in large sections of the world and secure rights can help turn these assets into development opportunities (*well established*). Indigenous populations, the poor, landless and women are among the groups most vulnerable to the implications of unequal landownership and access. Estimates suggest that only about 10 per cent of formal land rights are registered or recorded worldwide. Without formal recognition and protection of their land rights, communities in some countries face loss of land

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due to land acquisition, land grabbing and land leasing amid fear of food scarcity and rising food prices. Around the world, 26.7 million ha of agricultural land have been transferred into the hands of foreign investors since 2000. {8.5.3, 8.5.4}

Unequal tenure of land resources is a critical challenge for sustainable land management (*well established*). Tenure-security of indigenous peoples' lands can generate billions of dollars' worth of benefits (carbon sequestration, reduced pollution, clean water, erosion control) and a suite of other local, regional and global 'ecosystem services'. These benefits far outweigh the costs of securing land tenure. {8.5.3}

Continuing on the current track, it will be difficult to achieve the land degradation neutrality target adopted in the United Nations Conference on Sustainable Development (Rio+20) (*well established*). Assessments based on satellite data show that land degradation hotpots cover about 29 per cent of global land area. However, there is variance between different data sets and disagreement between methods. About 3.2 billion people live in these degrading areas. Investing in avoiding land degradation and the restoration of degraded land makes sound economic sense; the benefits generally far exceed the cost. Innovative technologies, land management strategies and land-resource stewardship at different scales (e.g. good agricultural practices, sustainable forest management, agro-silvopastoral production systems, agricultural innovation, payment for ecosystem services, land restoration, land titling) need to be more effectively promoted and adopted at local, regional, international and national levels. These alternatives also contribute to climate change resilience. Existing multilateral environmental agreements provide a platform of unprecedented scope and ambition for action to avoid and reduce land degradation and promote restoration. {8.6.1; 8.6.3}

Decreasing the gender gap in access to information and technology, and access to and control over production inputs and land, could increase agricultural productivity and reduce hunger and poverty (*well established*). New policies should explicitly target indigenous peoples, women, family farmers, pastoralists and fishers, so these groups can have secure and equitable access to land, inputs, knowledge, resources, markets, financial services, opportunities for adding value and non-farm employment. {8.6}

Minimizing food losses and waste will have significant environmental, social and economic benefits in supporting global food security (*well established*). Where waste cannot be prevented, opportunities to recover value from this waste stream, such as conversion to compost, liquid fertilizers, biogas or higher value end-use products such as animal feed protein or biochemicals, should be pursued. {8.6}

8.1 Land resources and the Sustainable Development Goals

Land is complex to define as it has multiple interconnected dimensions (e.g. land as a provider of resources and services, as shelter, as property, as a key to cultural identity) (United Nations Convention to Combat Desertification [UNCCD] 2017). In this chapter, we emphasize land as a provider of food, fodder, fibre and forest products. Its ability to provide ecosystem services that regulate ecological processes is treated in Chapter 6 and the latest Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) assessment reports (see below). Land is where a large proportion of food is produced, therefore it is closely related to Sustainable Development Goal (SDG) 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture. Specific targets for this goal include ensuring access to sufficient, healthy and nutritious food, especially for the most vulnerable groups. Furthermore, SDG 2 is closely related to increasing productivity through sustainable food production systems that are more resilient under increasing threats of climate change, and for maintaining and improving soil quality for future generations. Sustainable and more resilient food production systems require working towards gender equality and reducing other forms of inequality (SDG 10) since men and women do not have equal access to land resources in many parts of the world.

Land is the home of terrestrial biodiversity, is associated with food production, is where people live and where most economic activities take place. Over 54 per cent of the global population lives in urban areas (United Nations 2015a) and this poses additional challenges for land management: how to deal with hazardous pollutants and chemicals and their impacts on people and the environment. Pollution on land is becoming an important pressure, and human-generated waste and chemicals are impacting the health of people and the functioning of many ecosystem processes (SDGs 3, 15).

Additionally, human use of land is exerting enormous pressure on land resources, privileging short-term gains over long-term sustainability (UNCCD 2017), decreasing the supply of many ecosystem services (nature's contributions to people). The Millennium Ecosystem Assessment presented evidence that we are living beyond our means (Millennium Ecosystem Assessment 2004) and that ecosystems' abilities to provide us with food, fibre, forest resources, fodder and other biodiversity-related benefits are threatened. The recent IPBES report on land degradation and restoration reinforces this critical message (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES] 2018). A healthy planet is the basis for development, and sustainable land-resource management is at the core of this challenge.

8.2 Setting the stage for GEO-6: the GEO-5 legacy

The main messages of the fifth report of the *Global Environment Outlook* (GEO-5) could be extrapolated to GEO-6. Perhaps the most important difference is the recognition of climate change as a driver of environmental change, and how it has the potential for altering land resources on its own (see Chapter 2). Climate change usually exacerbates ecosystem degradation and a more variable climate degrades ecosystems more strongly.

Another difference is the increasing recognition of the critical function that clear property rights play for land-resource stewardship and the crucial role of rural inhabitants in land conservation. The Land Rights Now initiative (http://www.landrightsnow.org) states that 2.5 billion people depend on land resources that are held, managed or used collectively. These people manage and protect 50 per cent of land, but only have legal ownership of 10 per cent. Clear property rights usually result in better management and stewardship of land resources (Lawry *et al.* 2017). Without them, these people are vulnerable to land dispossession in the hands of powerful actors (e.g. multinationals, governments).

Finally, there is increased concern over how land resource degradation is leading to widespread migration and even conflict. Since recording of these instances began in 2015, the Environmental Justice Atlas (https://ejatlas.org/) has listed more than 2,000 cases of socioenvironmental conflicts across the globe where land mismanagement, largely due to poor governance, has led to land degradation, conflict and/or dispossession of resources.

8.3 Drivers and pressures

8.3.1 Population

As chapter 2 notes, population growth is a key driver of land-use transformation with its associated environmental impacts. In the developing world, particularly Africa, there will be a doubling or tripling of population by the mid-21st century (United Nations 2014). In contrast, by 2050 developed countries will experience only small increases or even decreases in their population (United Nations 2015). Since the developed world has already entered a post-industrial society based increasingly on the tertiary sector, it is expected to be more stable in terms of land use, while developing countries are currently experiencing a rapid transition from agrarian societies to the industrial regime, with consequent radical change in land- and resource-use patterns (Haberl *et al.* 2011).

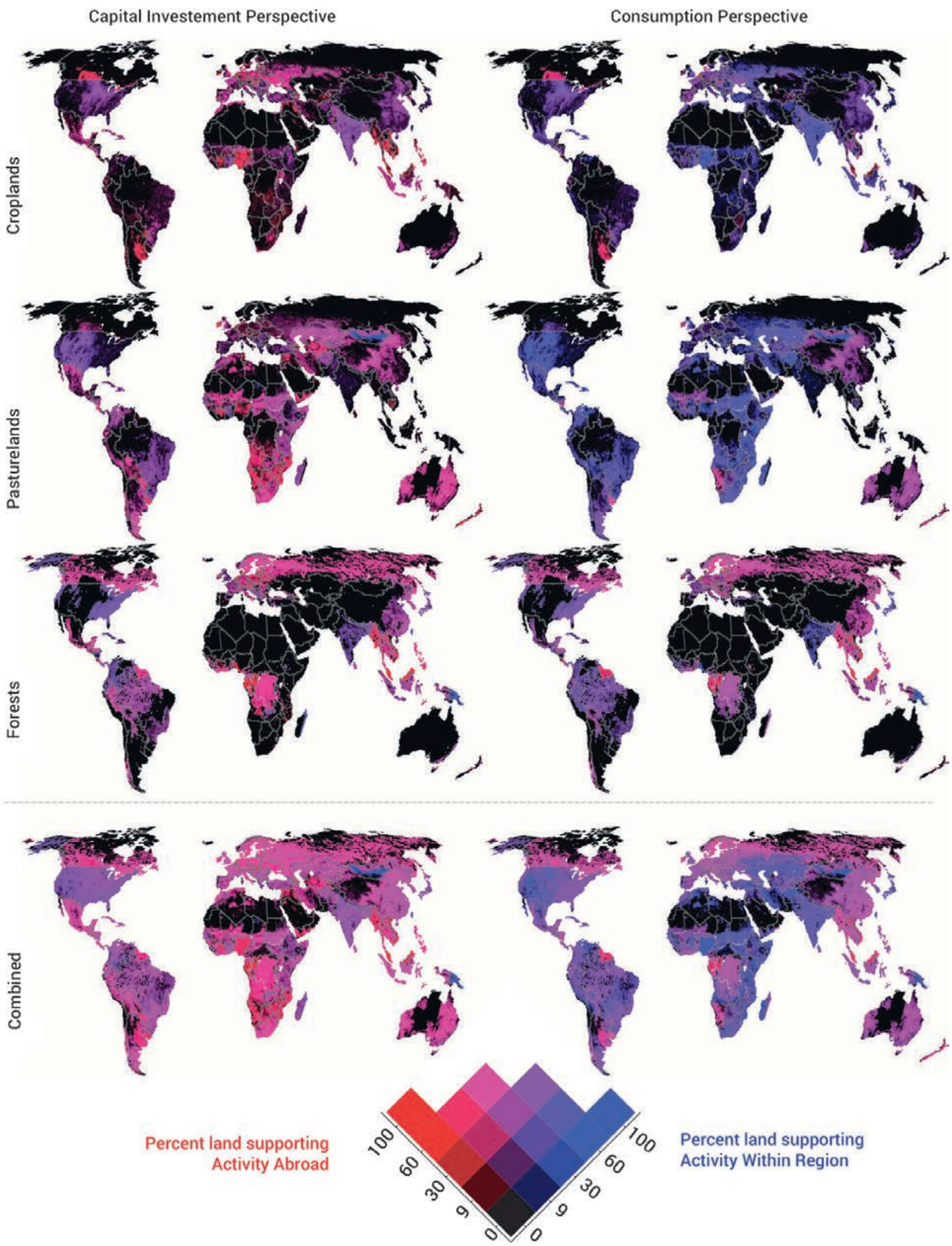
Population growth can present a serious threat to the inherent limits of land to provide food, shelter and appropriate nutrition for local communities. However, impacts depend on specific socioeconomic contexts and are present mostly in developing countries. For example, a study of land-use change in north-western Ethiopia (1972-2010) shows conversion of 62 per cent of woodland into cropland, with high environmental costs (dust storms, droughts, severe soil erosion), due to population growth, but also because of attractive subsidies to farmers (Zewdie and Csaplovies 2015). Most studies on the subject recognize the importance of rural-to-urban migration for mitigating some of the negative impacts of population growth on land resources in rural areas. Some natural increase in population in rural areas can now be absorbed outside the country due to intraregional infrastructure improvements, as observed in Africa where a majority of migrants circulate within the continent looking for economic opportunities (Awumbila 2017).

8.3.2 Urbanization

Urban and rural areas are interconnected in terms of people, resources and services. Rural areas are connected to urban regions through networks of roads, information technology, electricity and trade. Meanwhile, urban areas are increasingly reliant on land-based resources yielding nature's contributions to people such as clean water, food and fibre. Urbanization can both positively and negatively impact these flows and functions and influence the economy and development of peri-urban and rural areas (Brenner and Schmid 2014). Cities operate within ecosystems that usually extend beyond jurisdictional boundaries (Solecki and Marcotullio 2013), requiring new methods to accurately measure the extent of urbanization to aid decision makers and civil society in responding to existing and emerging challenges (United Nations 2016). Urban demands for food, water, fibre and construction materials have established strong linkages between cities, rural areas and even regions in other countries. These linkages, also known as teleconnections, mean that land use in rural areas increasingly depends on demands from distant, urban agglomerations (Seto *et al.* 2012; Bergmann and Holmberg 2016). Urban infrastructure (energy, water, buildings and transportation) and food supply are particularly reliant on transboundary supplies (Kennedy and Hoornweg 2012; Ramaswami *et al.* 2012; Ramaswami *et al.* 2017).

Rural-to-urban migration continues and it has multifaceted impacts on land use through changing diets and demands on infrastructure and housing, as well as the ability of land to continue providing nature's contributions to people (UNCCD 2017). Much of the increase in population in built-up areas has taken place in disaster-prone regions such as within 10 metres (above sea level) of low elevation coastal zones (Seto *et al.* 2011; Paresi *et al.* 2016).

Figure 8.1: Different perspectives on the globalization of lands in 2007 (Eckert IV projection)



The figure illustrates how capital and consumption are linked regionally and globally for different lands' economic activities.

Source: Bergmann and Holmberg (2016).

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8.3.3 Economic development

Globalization forces exert increasing pressures on land systems and their functions, leading to landscape change (Fischer-Kowalski and Haberl 2007; Henders and Ostwald 2014; Schaffartzik *et al.* 2015). Global trade and capital flows influence land use (e.g. agriculture, forestry) in developing countries (Bergmann and Holmberg 2016) (**Figure 8.1**, **Figure 8.2**). These flows of agricultural goods require transport and storage, which may increase economic and environmental costs and may also lead to the deterioration of the nutritional value of food, increase risks of disease transmission and generate food waste (UNEP 2016a). The significance of pressures on land tenure and land access is discussed in further detail in Section 8.5.3.

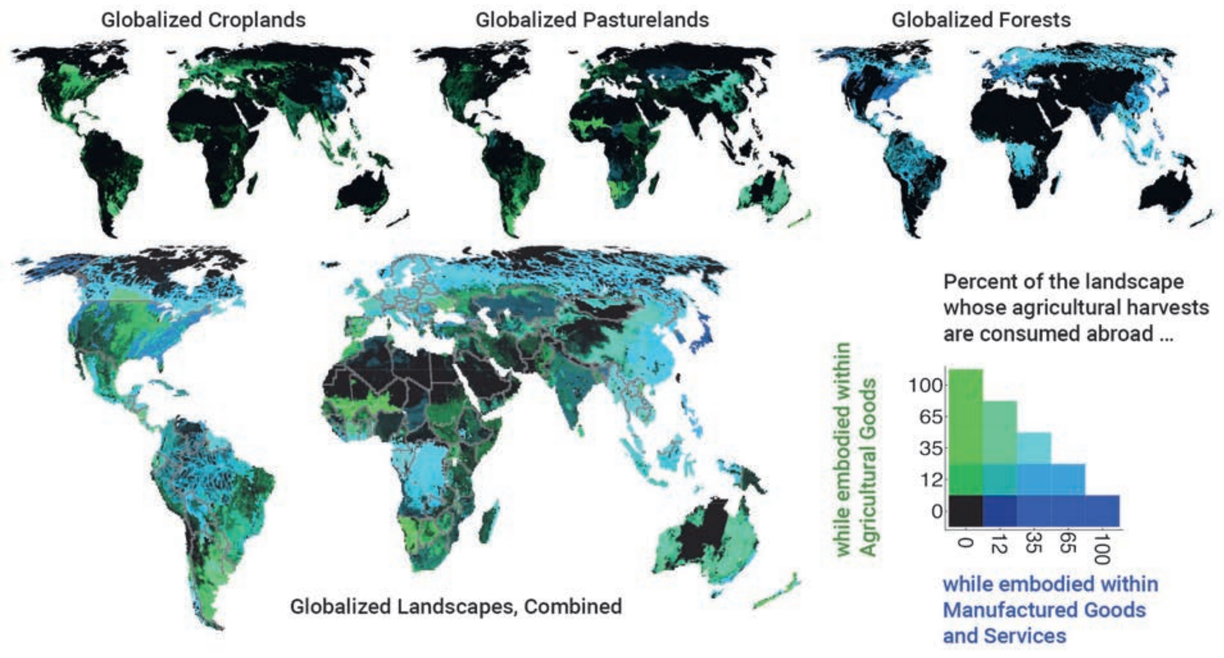
8.3.4 Technology and innovation

Around the globe, fast advancing technologies shape production and consumption, and drive patterns of land use and terrestrial ecosystems at various scales. Earth's big data and citizen science improve environmental monitoring and assessment, while allowing more public involvement (see Chapter 25).

Although it still has some limitations, satellite-based Earth observation has been combined with big data to track forest changes worldwide (e.g. Global Forest Watch, www.globalforestwatch.org; Terra-i, www.terra-i.org). Drones, powered by mobile technology, are becoming widely used to monitor biomass burning and unauthorized land-use conversion. The global explosion of cell phone access, and especially smartphones, can be used to democratize data access. Technological developments such as precision agriculture and drip irrigation are examples of more efficient agrochemical and water use.

Mobile communication and the Internet enable critical environmental information to spread within seconds to any corner of the world, rich or poor. Rural inhabitants in many parts of the developing world can use these technologies to improve land management with potential impacts on biodiversity conservation and land use (Chin 2018).

Figure 8.2: Relative roles played by agricultural commodities versus manufactures and services in globalizing lands (Eckert IV projections)



Source: Bergmann and Holmberg (2016).

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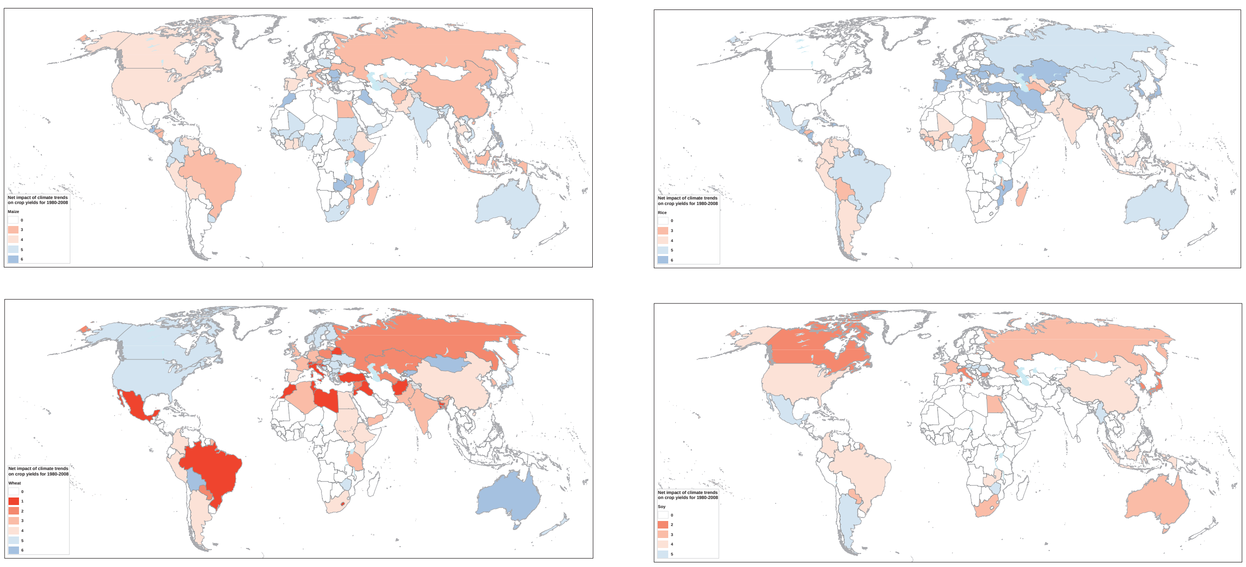
8.3.5 Climate change

Rising global temperature and changing rainfall patterns have already impacted terrestrial ecosystems and crop yields (see **Figure 8.3**) In tropical regions, the effects of higher temperatures will likely be greater than in temperate zones (Intergovernmental Panel on Climate Change [IPCC] 2014). Shifting rainfall patterns may benefit certain regions, but greater variability in precipitation (more frequent droughts) poses a risk to 70 per cent of global agriculture that is rain-fed (IPCC 2014). As the growing seasons change, yield growth has slowed (Lobell, Schlenker and Costa-Roberts 2011; Lobell and Gourdji 2012). Rising sea level due to climate change generates risks of coastal area loss and subsidence (IPCC 2014), threatening the livelihoods of many coastal inhabitants (Paresi *et al.* 2016) (see Section 8.3.5).

Increased concentrations of CO_2 in the atmosphere may benefit crop yields in certain regions through greater CO_2 fertilization (McGrath and Lobell 2013), while warmer temperatures could bring yield gains in high-latitude regions (IPCC 2014). At a global level, however, yields are expected to suffer as average temperatures and ozone concentrations in the troposphere continue to rise (Schlenker and Roberts 2009; IPCC 2014). Higher temperatures have led to increased distribution of certain weeds and pests (Pautasso *et al.* 2012) and have exacerbated existing stresses during certain growing periods (Gourdji, Sibley and Lobell 2013).

On the other hand, climate-smart agricultural practices such as minimum tillage and energy-efficient crops and practices present an opportunity for increasing the atmospheric carbon sink in soils and hence contribute to mitigation of climate change (Han *et al.* 2018). Similarly, efforts to reduce deforestation and forest degradation, conserve and enhance forest carbon stocks, and sustainably managed forests globally can contribute significantly to reducing greenhouse gas (GHG) emissions and to carbon sequestration in living biomass and forest products.

Figure 8.3: Estimated net impact of climate trends for 1980-2008 on crop yields by country



Source: Lobell, Schlenker and Costa-Roberts (2011).

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8.4 Key state and trends

8.4.1 Land-use dynamics

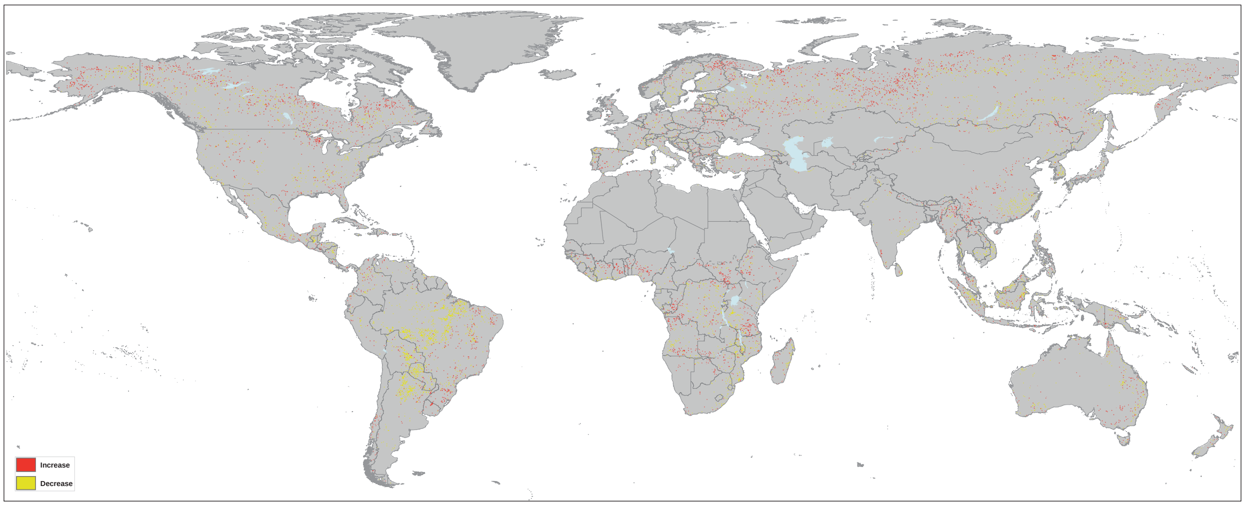
Land-cover change

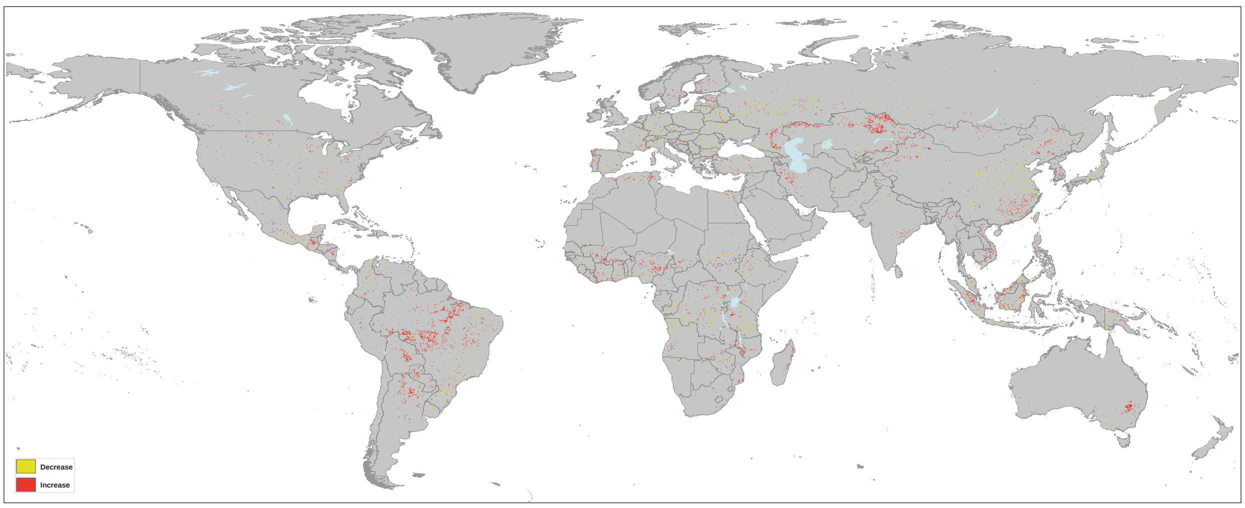
Land is extremely dynamic and land cover changes due to climatic, geologic or ecological processes. However, human land use, mostly agriculture, is currently responsible for most of the changes of land cover and its condition (Haberl 2015; de Ruiter *et al.* 2017; **Figure 8.4**).

Agricultural production needs to nearly double in the period 2012-2050 to meet increasing food, feed and biofuel demand (Food and Agriculture Organization of the United Nations [FAO] 2017a). Although the Food and Agriculture Organization of the United Nations (FAO) estimates that 1,400 million ha are available for expansion (Alexandratos *et al.* 2012), these are mostly in forests and other ecosystems with little disturbance, where nature's contributions to people such as clean water and climate regulation are generated (Machovina, Feeley and Ripple 2015). When possible, people abandon degraded land and expand production elsewhere. As land becomes abandoned, it may slowly start to regenerate: vegetation and wildlife begin to reclaim the spaces left by the abandoned land use, as the spontaneous regrowth of 362,430 km^2 of woody vegetation in Latin America (2000-2010) illustrates (Aide *et al.* 2013).

Global economic forces are shaping local land-use patterns. For example, modern mining is growing in scale due to increased global demand. This is compounded by declining ore grades, which means more ore needs to be processed to meet demand, with extensive use of open cast mining and its associated waste rock. Mining presents cumulative environmental impacts, especially in intensively mined regions,

Figure 8.4. Changes of global forests (top) and cropland (bottom) 1992-2015 based on European Space Agency land cover data time series





Source: Adapted from European Space Agency (2015).

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including areas subject to hydraulic fracturing for oil. A map of areas in Colombia, Ecuador, Peru and Bolivia (**Figure 8.5**) shows land areas that are or have the potential to be exploited for mining, gas and oil highlights the conflict that can emerge from land-use competition (Asociación Pro Derechos Humanos [Aprodeh] *et al*. 2018).

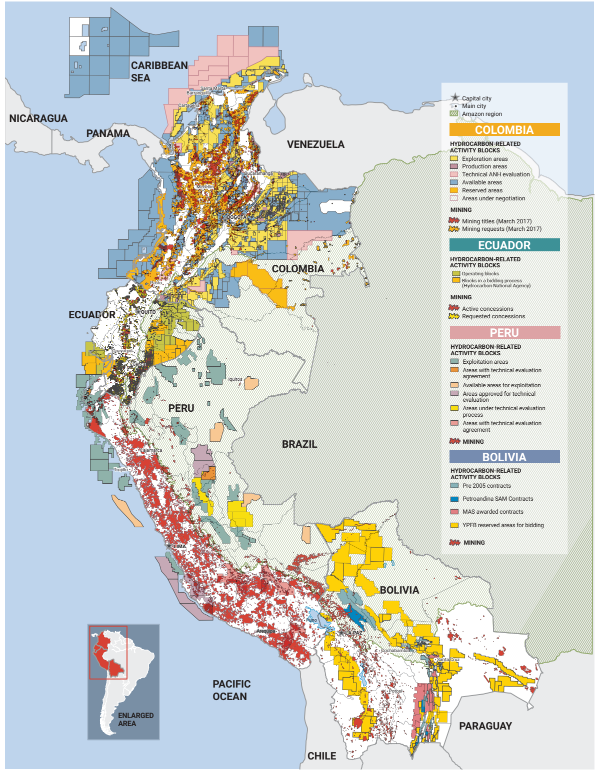
Agricultural dynamics

Food production accounts for the largest anthropogenic use of land – 38 per cent of ice-free land (Holmes *et al.* 2013) or 50 per cent of habitable land (Roser and Ritchie 2018). Within this, the livestock sector dominates, using more than three-quarters of agricultural land for feed production, pasture and grazing (Foley *et al.* 2011; Roser and Ritchie 2018) (**Figure 8.6**).

Primary food production accounts for about 23 per cent of agricultural land use (Figure 8.6), although in recent years a growing proportion of land has been used to grow crops for biofuel production (Cassidy *et al.* 2013). By 2009, biofuel production accounted for 2 per cent of total ice-free land use and is expected to increase to 4 per cent by 2030 (FAO 2009). Agricultural area has decreased by about 1 per cent since 2000 (**Figure 8.7**; FAO 2017b). Although a small drop, this figure does not consider land degradation (see below) or how, despite the reduction in the total agricultural area, this may mask the abandonment of degraded lands and the expansion of the agricultural frontier elsewhere.

While the global harvested crop area increased by 23 per cent between 1984 and 2015, global crop production rose by 87 per cent (FAO 2017b), mostly through monoculture farming. However, these food production systems might be associated with environmental degradation and biodiversity loss (Benton, Vickery and Wilson 2003; Foley *et al.* 2011; UNCCD 2017).

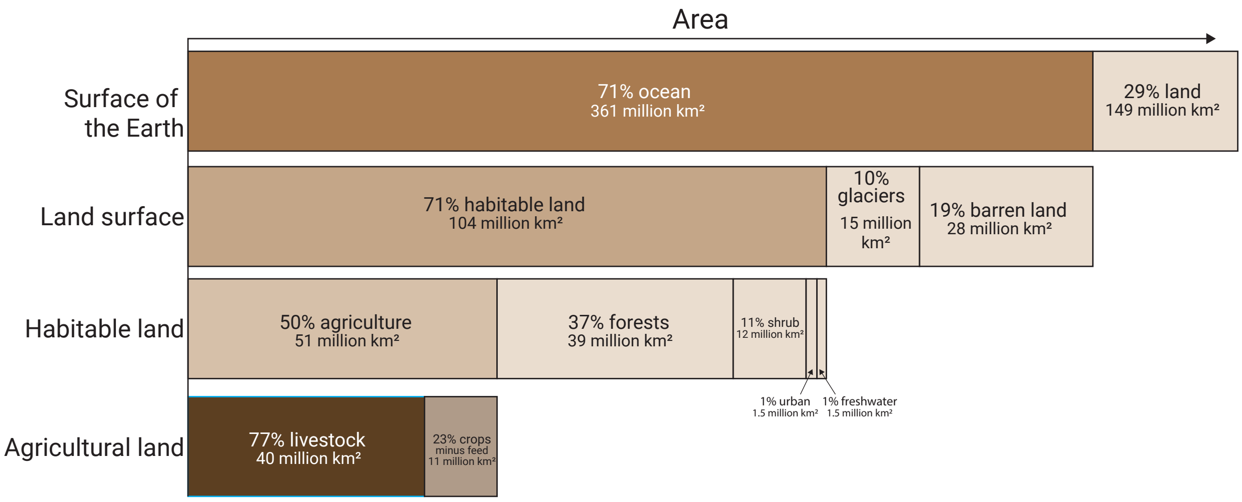
Figure 8.5: Areas designated for extractive activities in the Andean region (South America)



Source: Aprodeh et al. (2018). Adapted from a map compiled in 2018 by the Bolivian Information and Documentation Center (Cedib) from official country sources available on the internet

Figure 8.6: Global area allocation for food production

The breakdown of the surface of the Earth by functional and allocated uses, down to agricultural land allocation for livestock and food crop production, measured in millions of square kilometres. The area for livestock farming includes land for animals, and arable land used for animal feed production.



Source: FAO (2017b); Roser and Ritchie (2018).

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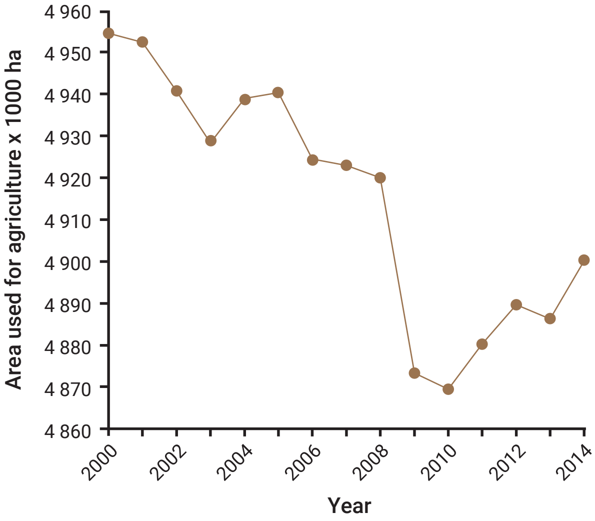
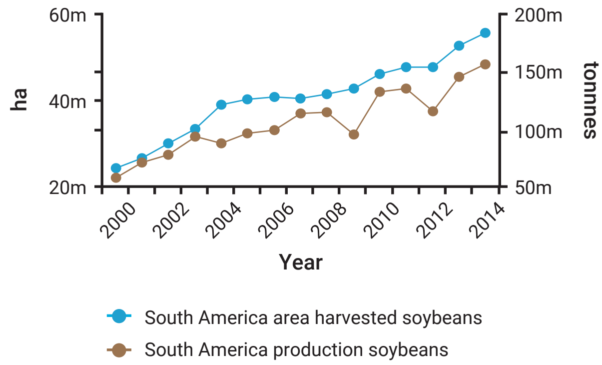
Figure 8.7: Agricultural area 2000-2014



Agricultural area includes the area under agriculture (arable land), permanent crops, and pasture and meadows in a given year.

Source: FAO (2017b).

Figure 8.9: Soybean production in South America 2000–2014



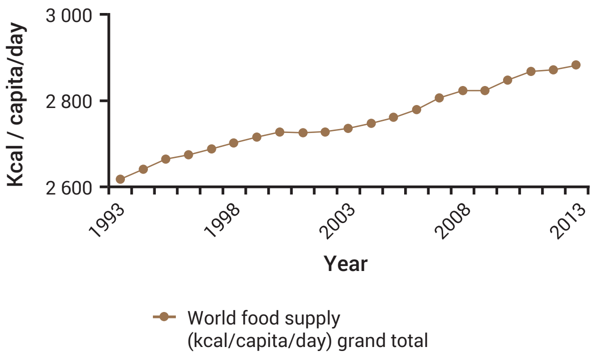
Source: FAO (2017b).

Similarly, per capita daily food supply in the world increased 10 per cent between 1993 and 2013 (**Figure 8.8**; FAO 2017b). Many areas have been converted to cropland as the demand for flexible crops increases (Borras *et al.* 2012). Grasslands in Argentina, Bolivia, Brazil, Paraguay and Uruguay have been converted into soybean fields mostly for export (Graesser *et al.* 2015). Soybean area has more than doubled since 2000 (**Figure 8.9**). The areas harvested in South America and North America account for approximately 47 per cent and 30 per cent, respectively, of the soybean area worldwide (FAO 2017b).

A similar process occurs with oil palm production in South-East Asia. The area planted with this crop has increased since 2000 (**Figure 8.10**). In 2014, more than 68 per cent of total oil palm crop area was in this region and 85 per cent was in Asia (FAO 2017b).

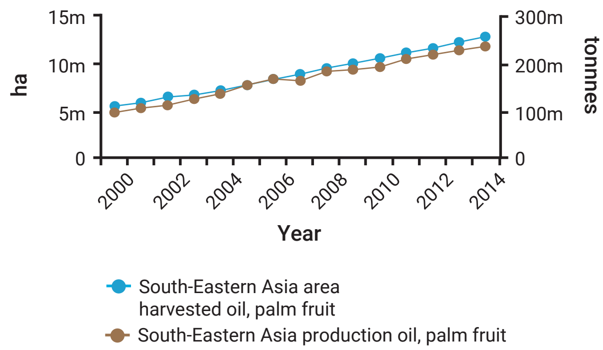
The expansion of oil palm plantations in South-East Asia has been at the expense of forests. This increase has been the result of the rising demand for biofuels and edible oil. In Kalimantan, Indonesia, from 1990 to 2010, some 90 per cent of land converted to oil palm plantations were forested (Carlson *et al.* 2012). From 2001 to 2015, more than 9.5 million ha were deforested on Borneo (World Resources Institute [WRI] 2018). In the oil-palm plantations in the lowlands of peninsular Malaysia (2 million ha), Borneo (2.4 million ha) and Sumatra (3.9 million ha), Koh *et al.* (2011) found that about 880,000 ha of tropical peatlands in the region had been converted to oil palm plantations by the early 2000s. By 2010, some 2.3 million ha of peat-swamp forests were deforested but were not yet converted to oil palm plantations.

Figure 8.8: Food supply in the world (kcal/capita per day)



Source: FAO (2017b).

Figure 8.10: Production of oil palm fruit in South-East Asia



Source: FAO (2017b).

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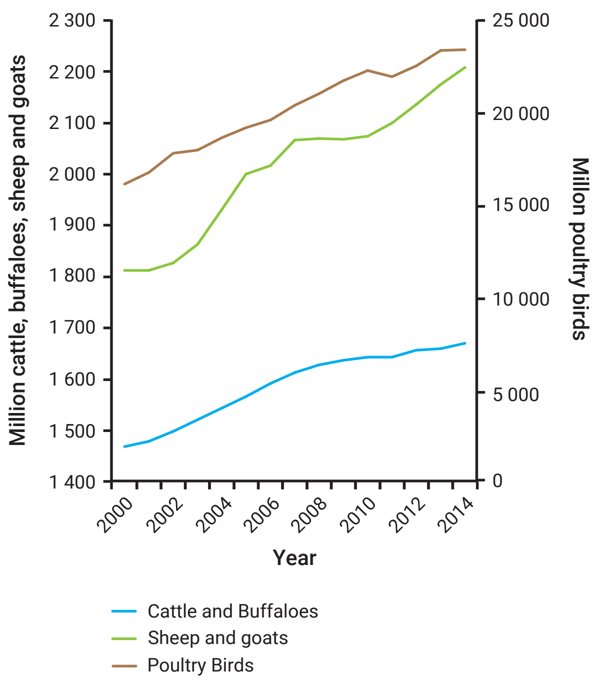
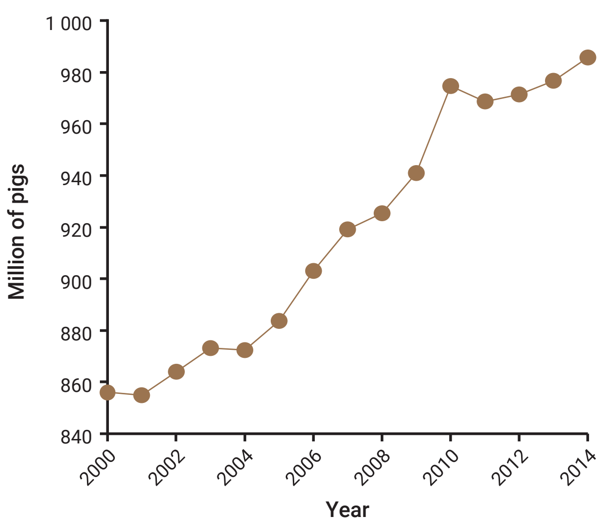
Global livestock populations increased between 2000 and 2014 (**Figure 8.11**, **Figure 8.12**). While human population grew by nearly 19 per cent, numbers of cattle and buffalo, goat and sheep, poultry birds and pigs grew by 13.8 per cent, 21.9 per cent, 45.4 per cent and 15.1 per cent respectively. However, the increase in livestock numbers has been accompanied by a decrease in pasture and permanent meadows (**Figure 8.13**). These high growth rates are mostly associated with more intensive livestock production systems that rely on the efficient use of animal feed (Mottet *et al.* 2017).

Figure 8.11: Numbers of herbivores and poultry



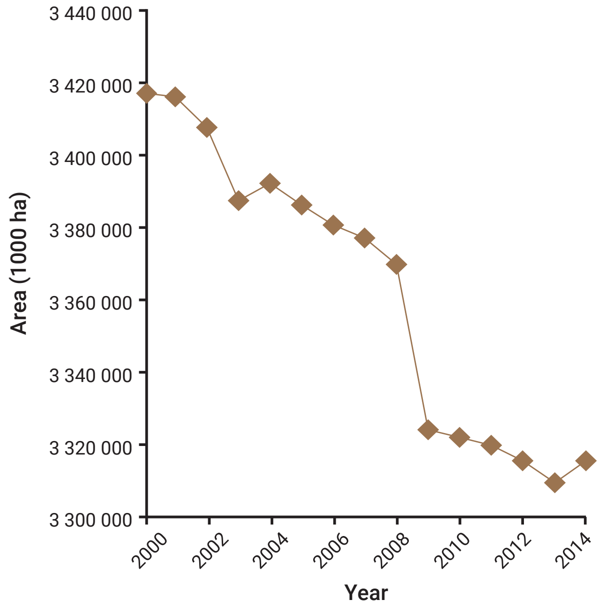
Source: FAO (2017b).

Figure 8.12: Numbers of pigs, 2000-2014



Source: FAO (2017b).

Figure 8.13: Permanent meadows and pastures (1,000 ha)

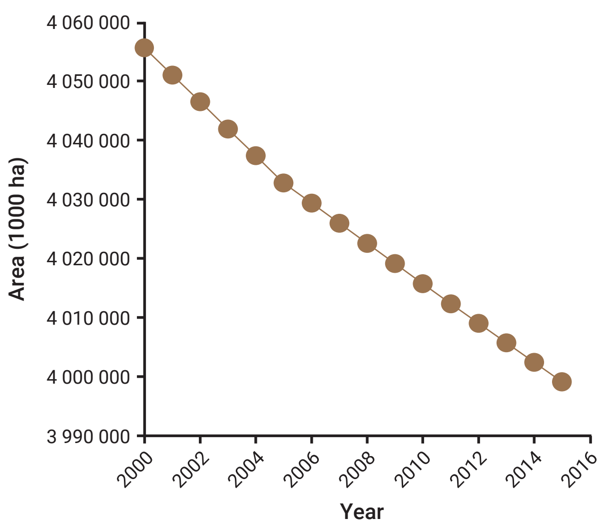


Source: FAO (2017b).

Forest dynamics

Forests continue to decline (**Figure 8.14**). In 1990, they represented 31.6 per cent of the planet's land area. This decreased to 30.6 per cent in 2015 (FAO 2015a), but forest loss rates are declining. In the 1990s, about 10.6 million ha of natural forests were lost each year. For the period 2010-2015, this rate had dropped to 6.5 million ha/year. At the same time, the increase in planted forests was about 3.2 million ha/year; by 2015 they accounted for 7 per cent of the global forest area mostly concentrated in high-income countries (FAO 2015a; **Figure 8.15**). Forest loss rates differ among regions and, while the global trend is towards forest loss, many regions, especially

Figure 8.14: Forest land in the world, 2000-2015



Source: FAO (2017b)

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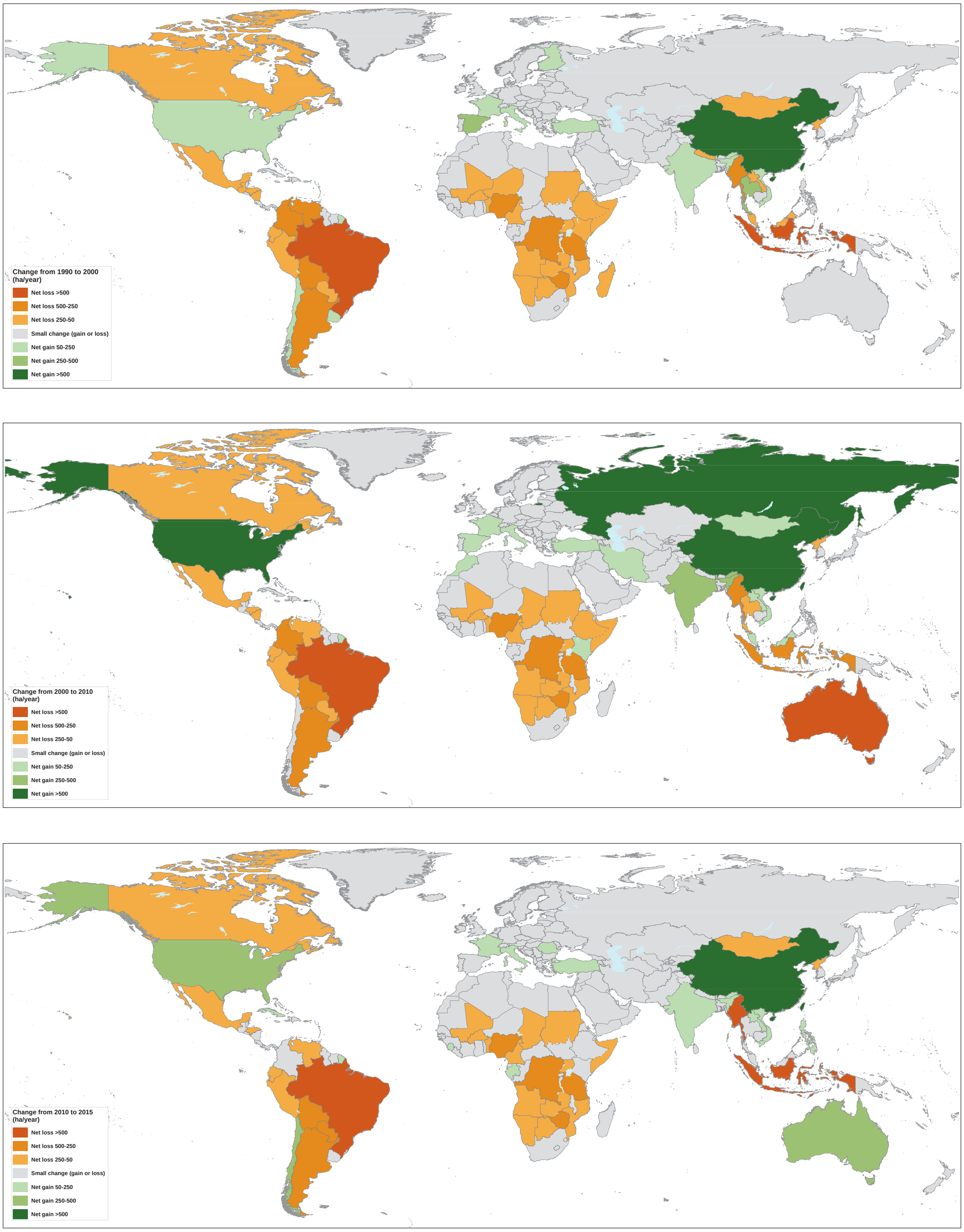
Figure 8.15: Forest area annual net change, (1990-2000, 2000-2010, 2010-2015)



Source: FAO (2015a).

8

in more developed countries, are showing an increase in forest cover, though some of this forest is as plantations. Natural forests continue to decline in most areas of the world (**Figure 8.15**), threatening the supply of essential benefits to people. For example, as deforestation increases in the Amazon rainforest, rainfall has been decreasing. Recent estimates indicate that a critical tipping point for the hydrological cycle in this part of South America will be reached if deforestation reaches 20-25 per cent of the original forest cover in the Amazon basin (Lovejoy and Nobre 2018). In the last 50 years, 17 per cent of the original extent of the Amazon rainforest has been deforested (World Wide Fund for Nature [WWF] 2018) and the forest cover continues to decrease (Butler 2017; WRI 2018; WWF 2018).

Urban expansion

Built-up areas occupy a very small fraction of land. However, since 1975 urban clusters (i.e. urban centers as well as surrounding suburbs) have expanded approximately 2.5 times, accounting for 7.6 per cent of global land area (Paresi *et al.* 2016). Between 1975 and 2015, built-up areas doubled in size in Europe, while in Africa they grew approximately fourfold. Cities have grown in both regions, but urban population remained relatively constant in Europe while it tripled in Africa. This means that the built-up area per-capita is different across the world (Paresi *et al.* 2016). In addition, urban expansion leads to landscape fragmentation and urban sprawl. As cities expand, urban land uses usually take over agricultural lands (van Vliet, Eitelberg and Verburg 2017), and the demand for food, fibre and minerals can transform previously unconnected locations (Seto *et al.* 2012; van Vliet, Eitelberg and Verburg 2017). In Latin America, a pervasive spatial expansion (almost 84 per cent of the population lives in cities) has been observed leading to less compactness (Inostroza, Baur and Csaplovics 2013).

By covering the ground with impervious surfaces, cities affect the hydrological cycle and soil function. They also generate what are called urban heat islands. But they can also be more efficient in providing access to education, housing, clean water and electricity. Since 2000, cities have incorporated more green spaces and trees (Paresi *et al.* 2016).

While cities are expanding into hinterlands, there is increasing recognition of the value of preserving natural systems (e.g. lakes and natural water bodies) as well as constructing enhanced-engineered urban green infrastructures (e.g. parks, urban farms, bioswales). These have potential to offer multiple benefits that can enhance biodiversity and human well-being, including water management, flood risk mitigation; heat island mitigation (Pataki *et al.* 2011); emotional well-being, health (Groenewegen *et al.* 2006; Pataki *et al.* 2011; White *et al.* 2013; Sturm and Cohen 2014; World Health Organization [WHO] 2017); pollution capture; and cultural amenities.

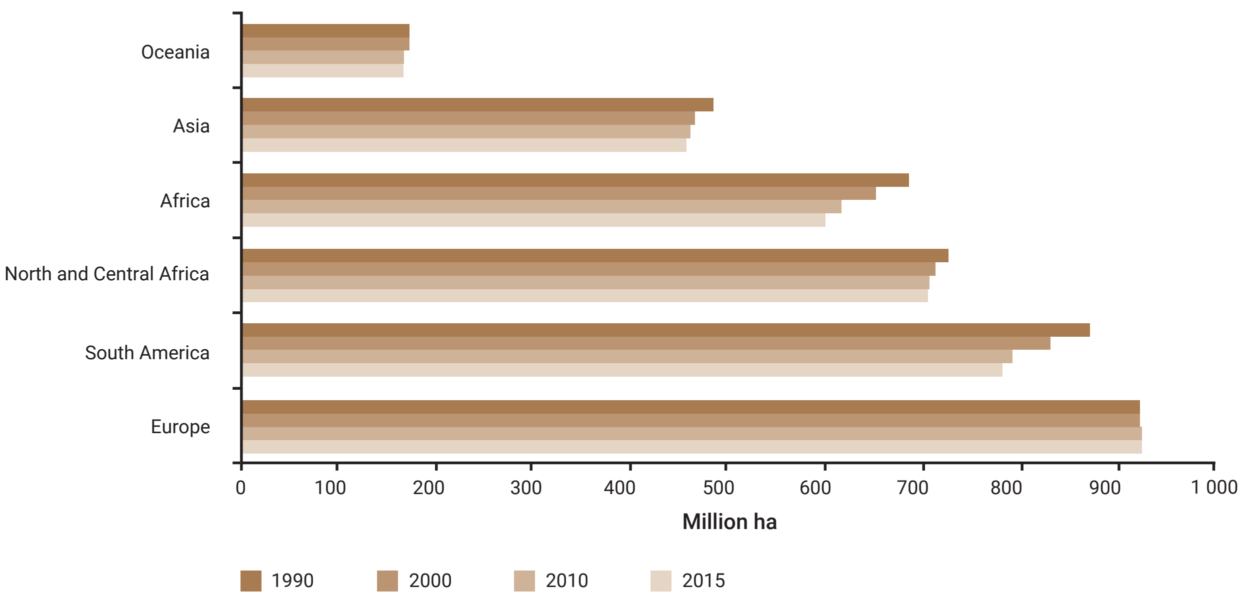
In 2015, some 52 per cent of people lived in high-density urban centres, 33 per cent in towns and suburbs and 15 per cent in rural areas (Paresi *et al.* 2016). While many cities continue to grow in population and expand, others experience population decline. Shrinking cities leave behind vacant parcels as part of a cycle of growth and decline, whose management offers new opportunities to enhance the environment.

8.4.2 Land quality dynamics

Land degradation and crop production

Land degradation involves the decline or disruption of land ecosystem services, including net primary production (NPP) (Le, Nkonya and Mirzabaev 2016). It results from different processes: soil erosion, salinization, compaction and contamination, organic matter decline, forest fires and

Figure 8.16: Natural forest area by region, 1990-2015



Source: FAO (2015a).

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overgrazing (Jones *et al.* 2012; Kosmas *et al.* 2014). Decline of NPP is also a reduction in microbiological activity and water retention capacity, lower hydraulic conductivity, and decreasing soil resistance, among others (Soane *et al.* 2012). FAO (2015b) estimates current land degradation at 12 million ha/year. It is estimated that annual losses from ecosystem services resulting from land degradation range between US$6.3 trillion and 10.6 trillion (The Economics of Land Degradation [ELD] 2015). While degradation could be a biophysical phenomenon, the causes and implications are also economic and social. Many efforts attempt to assess observable land degradation trends, scales and consequences. However, different definitions of degradation and methods used to measure them lead to differing results regarding its magnitude, where it takes place, its effects and its costs (FAO 2018). A recent estimate using satellite imagery estimates that 29 per cent of global land area is degraded, while improvement has occurred in 2.7 per cent of global land area in the last three decades, and about 3.2 billion people live in the degrading areas (Le, Nkonya and Mirzabaev 2016). Reducing land degradation and increasing land restoration are critical for providing necessary ecosystem services that contribute to life on Earth and human well-being (IPBES 2018).

Desertification

The United Nations Convention to Combat Desertification (UNCCD) defines desertification as "land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities" (UNCCD 1994). However, desertification is still a highly controversial issue usually leading to expert disagreement (Reynolds and Smith 2002; Bestelmeyer *et al.* 2015). The extent of desertification ranges from 15 per cent to 63 per cent globally as well as 4 per cent to 74 per cent for drylands (Safriel 2007), and can be equally variable within a country like Mongolia, where degradation estimates range from 9 per cent to 90 per cent (Addison *et al.* 2012).

Recent research (Global Assessment of Soil Degradation [GLASOD]) shows that previous generalizations claiming that land degradation is occurring in semiarid areas worldwide is not supported by satellite-based observations (de Jong *et al.* 2011; Fensholt *et al.* 2012; Cherlet *et al.* 2018). Desertification and drought research in the Sahel indicate that the first process is not taking place (Behnke and Mortimore 2016). This trend may be explained by increasing precipitation, as well as by lower pressure on land due to outmigration (Olsson, Eklundh and Ardö 2005). However, current climatic conditions in the Sahel appear to be still below the more humid conditions of 1930-1965 (Anyamba and Tucker 2005; Nicholson 2013).

A positive trend is also observed in semi-arid areas of China where human actions might explain the 'expansion of desertification' between 1980 to 1990, although conservation activities have begun to reverse these trends (1990-2000) (Xu *et al.* 2009). Recent modelling results indicate that global greening might also be caused by CO_2 fertilization, nitrogen deposition and climate change (Zhu *et al.* 2016).

Recognizing the inherent complexity underlying land degradation, the recent edition of the World Atlas of Desertification (WAD) (Cherlet *et al.* 2018) presents several global data sets of biophysical and socioeconomic processes that, individually or combined, can contribute to land degradation (Reynolds *et al.* 2011; Bisaro *et al.* 2014).

Soil salinization

In arid and semi-arid regions, lack of adequate drainage in irrigated areas triggers salt accumulation in the root zone, negatively affecting crop productivity and soil properties (Qadir *et al.* 2014). In some countries, soil salinization affects half of irrigated land (Metternicht and Zinck 2003). Other sources suggest that about 33 per cent of the globally irrigated area has declining productivity due to inadequate irrigation, causing waterlogging and salinization (Khan and Hanjra 2008). Several studies of grain yield losses due to salinization indicate grain yield losses of 32-48 per cent on average (Murtaza 2013). The global annual losses in irrigated crops caused by salt-induced land degradation could be about US$27.3 billion due to lost crop production (Qadir *et al.* 2014). The costs of inaction on these lands may result in 15-69 per cent revenue losses depending on the type and intensity of land degradation, crop variety and irrigation water quality and management (Qadir *et al.* 2014). Additional losses, which are not included in these estimates, cover a wide range of issues – from deterioration of animal health to decline in property values of affected farms, among others (Qadir *et al.* 2014).

Permafrost thawing

Due to various feedbacks in the climate system, warming in the Arctic currently exceeds twice the mean global temperature rise (Taylor *et al.* 2013a). Sea ice is retreating, permafrost is thawing, and the ice-free season is lengthening, such that waves and warm air are increasingly degrading the thawing permafrost in the interior, as well coastal areas. The thawing of permafrost releases GHGs and alters the landscape. Thaw reduces soil and landform stability, increases erosion and affects arctic habitat, albedo and hydrology.


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By far, the largest fraction of the Arctic coastline consists of thawing permafrost (**Box 8.1**). Arctic permafrost coasts represent 34 per cent of all coasts on Earth. Coastal erosion rates have increased in recent years with values ranging around 1 metres /year. Erosion rates are highest along the Alaskan and Siberian coastlines, with maxima as high as 25 metre/year (**Figure 8.17, Figure 8.18**) (Günther *et al*. 2013; Overduin *et al.* 2014; Fritz, Vonk and Lantuit 2017). Therefore, increasing fluxes of organic carbon are released into the shelf seas. In some locations (Alaska), villages have had to be relocated further inland.

Box 8.1: Livelihood impacts in the Arctic

Reindeer (caribou) herds are an important part of Arctic ecosystems and integral to the livelihoods of indigenous peoples in Alaska, Arctic Canada, Scandinavia and the Russian Federation. Reindeer-herding communities depend on access to seasonal pastures. The seasonality and extent of pastures is changing as a result of climate change, impacting these pastoral communities.

Mining and resource extraction are also important in the Arctic. Changing Arctic conditions have made the construction and operation of the winter ice roads that supply mining outposts problematic. A warming climate has delayed freeze-up in the autumn (fall) and produced an earlier spring melt as well as thinner ice during the winter. This has led to shorter winter-road seasons. As the Arctic climate continues to warm, co-management institutions will find themselves increasingly dealing with trade-offs between sustainable development and sociocultural and ecological integrity of Arctic lands and livelihoods.

Figure 8.17: Coastal erosion rates at selected sites in the Arctic

Source: Overduin *et al.* (2014).

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Figure 8.18: Estimated coastal erosion threat in the Arctic

Source: Lantuit, Overduin and Wetterich (2012).

8.5 Key impacts

8.5.1 Food security

People are considered food secure when they always have availability of and adequate access to sufficient, safe, nutritious food to maintain a healthy and active life (FAO *et al.* 2017). The discussions in this section cover three critical issues–food availability, food access and food utilization.

Hunger and malnourishment

A sizeable proportion of the worlds' seven billion people are hungry and malnourished. Roughly one billion people have energy-deficient diets, and about one billion people suffer from diseases of energy surplus (called the 'hidden hunger' of micronutrient deficiencies) (Godfray and Garnett 2014). Although undernutrition is slowly declining, 155 million children under five years old, mostly in sub-Saharan Africa and South Asia, still suffer from stunted growth. Simultaneously, increasing numbers of people are suffering from overnutrition: more than 2 billion adults are overweight and 500 million are obese. Moreover, 88 per cent of countries face two or three forms of malnutrition (Development Initiatives 2017), and undernutrition and obesity increasingly coexist in the same households (FAO *et al.* 2017).

Malnutrition and changing consumption patterns put greater pressure on land resources making land-use decisions more important than ever before. Most food is sourced from terrestrial environments, though 17 per cent of global animal protein and 6.7 per cent of all protein consumption is from fish (FAO 2016). While food costs have fallen since 2008, this trend has not been constant (FAO 2017c), with volatility attributed to increased demand from rapidly developing countries and competition among first-generation biofuel producers

(The Royal Society 2008; Godfray *et al.* 2010). **Figure 8.19** shows vulnerability to food security using meteorological data for the period 1981-2010 and socioeconomic data representative of the year 2010. The results indicate that disasters such as floods and droughts are already having a strong impact on food security, and their frequency and intensity may increase as a result of climate change (Met Office Hadley Centre and World Food Programme 2018). In developing countries, agriculture absorbs about 22 per cent of the total damage and losses caused by natural hazards (FAO 2015b). Although disasters may impact rural livelihoods directly, the disruption to agricultural production and development can have negative repercussions across national economies, with devastating effects on food security, including in urban areas (**Box 8.2**).

Box 8.2: The Syrian crisis: droughts and land degradation as factors

The Syrian conflict has sometimes been labelled a 'climate conflict', since some of the root causes could be traced to the drought that affected the country between 2007 and 2010 (Kelley *et al.* 2015), the worst drought on record, causing widespread crop failure in the region. In Syrian Arab Republic, some 1.5 million people from rural farming areas migrated to the peripheries of urban centres, leading to a spike in food prices and eventually to the upheaval of the population (Kelley *et al.* 2015). The government could not provide migrants with housing, jobs and economic opportunities. This combination of factors contributed to a war that has now lasted several years and left the country in ruins, with about two-thirds of its 22 million population displaced.

Sustainable food production and efficient use

Approximately one-third of the food produced globally for human consumption is lost or wasted (Lipinski *et al.* 2013; United Nations Environment Programme [UNEP] 2015), together with the resources used in its production (land, energy, water, etc.) with the associated environmental impacts. Food losses and waste in 2007 utilized almost 1.4 billion ha of land, equivalent to about 28 per cent of the world's agricultural land area (FAO 2013). Based on food crop data for the period 2005-2007, food losses and waste consumed 23 per cent of total global fertilizer use (28 million tons/year) and 24 per cent of total freshwater resource use (Kummu *et al.* 2012). Furthermore, an estimated 99 per cent of food wastage at the agricultural production stage is produced in areas where soils are facing medium to strong land degradation, placing further stresses on these areas (FAO 2013, p. 47).

Approximately 56 per cent of total food loss and food waste occurs in developed countries, while 44 per cent originates from developing countries (Lipinski *et al.* 2013). This wastage generates GHGs. If food wastage were a country, it would be the third largest emitting country in the world (FAO 2015c). In the global South, losses are mainly due to the absence of food-chain infrastructure and lack of knowledge or investment in storage techniques. In the global North, pre-retail losses are lower but those arising from retail, food service and home stages of the food chain have grown dramatically in recent years (Godfray *et al.* 2010; **Figure 8.20**).

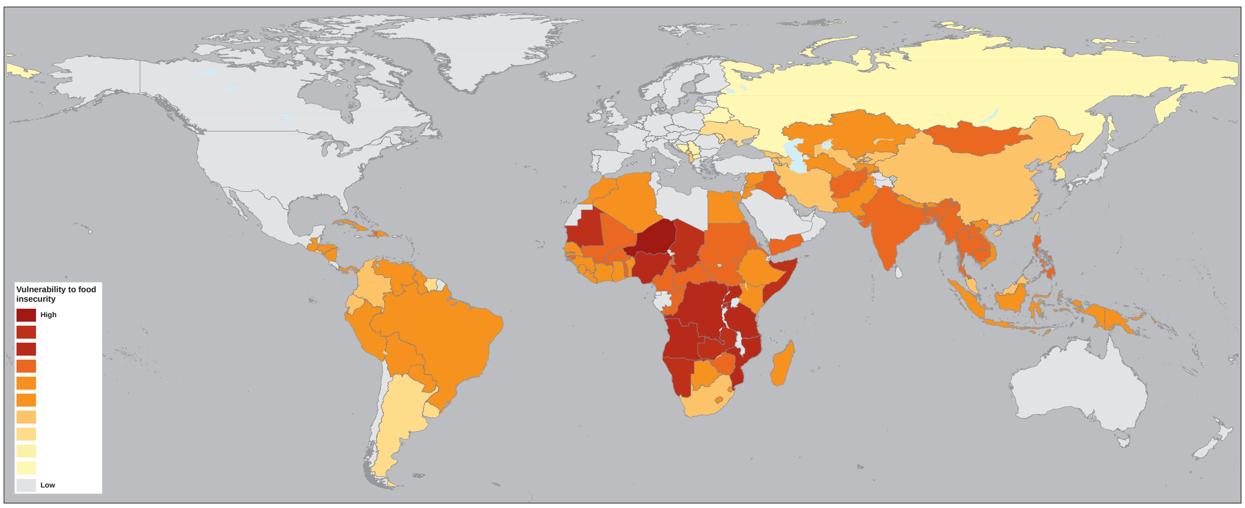
Sustainable intensification (e.g. agroecology-based production, agricultural innovation) is promoted as a sustainable land management strategy. Besides a sustainable food supply, it maintains nature's contributions to people, promotes human health and nutrition (Pretty, Toulmin and Williams 2011; Robinson *et al.* 2015).

Food security and food trade

International trade is increasingly important to meeting global food demand (Nelson *et al.* 2010; MacDonald *et al.* 2015). Population growth, urbanization and shifting dietary preferences have increased dependency on food imports (Msangi and Rosegrant 2011; Alexandratos *et al.* 2012; Porkka *et al.* 2013). The proportion of the global population living in food-deficit countries rose from 72 per cent in 1965 to 80 per cent in 2005 (Porkka *et al.* 2013).

Just under one-quarter of all food produced for human consumption is traded on international markets (D'Odorico *et al.* 2014; **Figure 8.21**).

Figure 8.19: Potential impacts of climate change on food security



Source: Met Office Hadley Centre and World Food Programme (2018).

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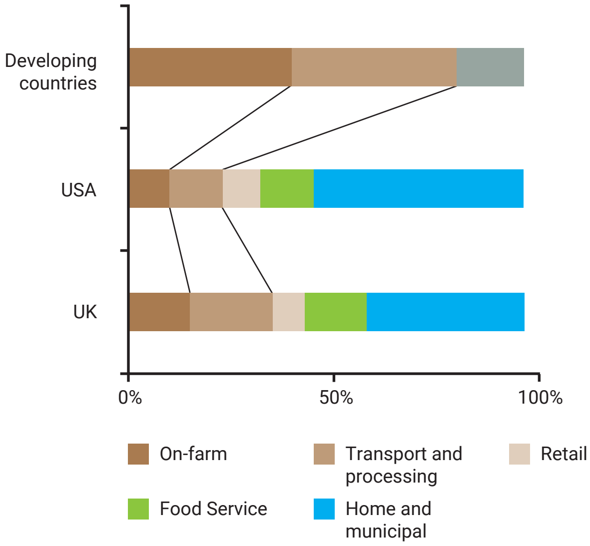
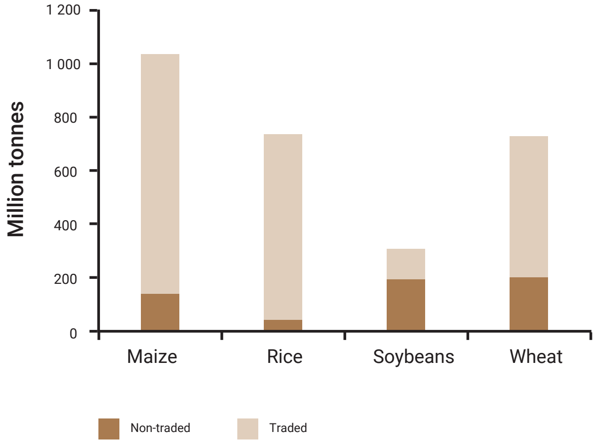
Figure 8.20: Make-up of total food waste in developed and developing countries



Retail, food service and home and municipal (subnational government sphere) categories are presented together for developing countries.

Source: Godfray *et al.* (2010).

Figure 8.21: Share of global production volumes traded internationally in 2014

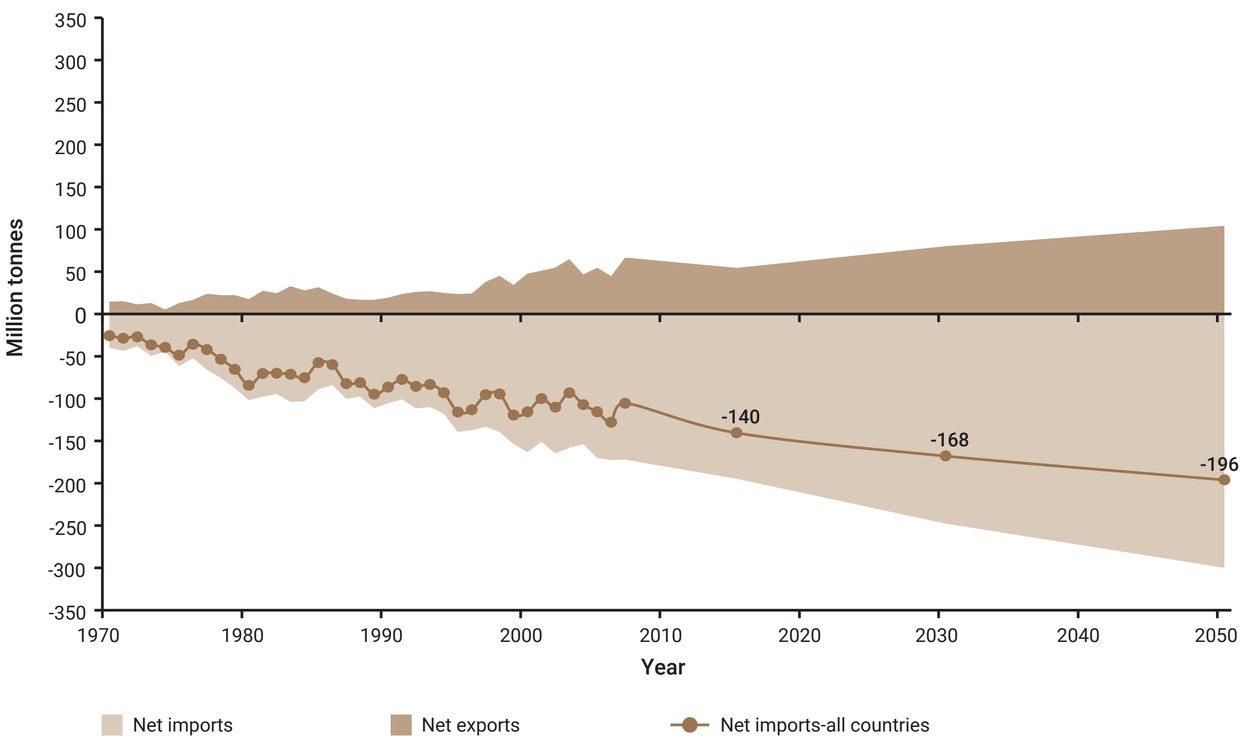


Source: Chatham House (2017); FAO (2017b).

Some low-income food-deficit countries have capacity to increase food productivity. But in others, including those where food insecurity is high – for example, Eritrea, Burundi and Somalia – food availability from domestic production is falling and the capacity to increase production is limited (Fader *et al.* 2016). Most developing countries have become increasingly reliant on imports to meet domestic demand, a trend that will likely continue through to 2050 (Alexandratos *et al.* 2012; **Figure 8.22**).

Global food supply has become dependent on the growing trade of a small number of crops grown in a few 'breadbasket' regions with increasing specialization (Khoury *et al.* 2014). This has led to lower food prices, with food-deficit countries benefiting from these food imports. However, the geographic

Figure 8.22: Developing countries: net cereals trade (million tons)



Net cereal imports have increased since 1970 and are expected to rise.

Source: Alexandratos *et al.* (2012).

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concentration of production increases systemic risk, as illustrated by recent spikes in international commodity prices due to poor harvests in certain regions (Puma *et al.* 2015; The Global Food Security Programme 2015). Due to climate change, such events may become more likely (Porter *et al.* 2014). Furthermore, the growing prevalence of certain crops in global food supplies has contributed to the increasing consumption of nutritionally poor food, some of which is highly processed (processed in a nutrient-poor manner), with serious consequences for human health (Khoury *et al.* 2014).

8.5.2 Human Health and land management

Health effects from mining

Adverse human health issues are also associated with mining and ore processing. While such operations generate employment and provide essential fuels and raw materials, residues such as lead affect air quality, posing a hazard especially to children, who are more likely to ingest such dust (Taylor *et al.* 2013b). The mining of some rare minerals, such as tantalum, often involves exploitation and even slavery (Gold, Trautrims and Trodd 2015).

Mining waste is one of the world's largest waste streams by volume, with the potential to cause significant environmental impacts, including abrupt and extensive land use change (Sonter *et al*. 2014; Murguía 2015; Hudson-Edwards 2016; Sonter *et al*. 2017). The Global Waste Management Outlook (UNEP 2015) estimates mining waste to be in the order of 10-20 billion tons per year. Mining waste will probably continue to grow, since companies are now turning to lower-grade ores, which typically generate more waste per unit extracted. However, mining waste should also be regarded as a potential resource within a circular economy (Lèbre and Corder 2015). Mining activities generate impacts on ecosystems and lead to soil contamination. Toxic and radioactive dust emissions from mining waste are a relevant health issue in many parts of the world (see Chapter 5). Water pollution also results from mining (acid metalliferous drainage and leakages from tailing management facilities) (see Chapter 9) (Hudson-Edwards 2016). In many parts of Latin America, mining activities have an important impact. For example, artisanal gold mining in the Amazon basin deposited an estimated 3,000-4,000 tonnes of mercury during the late 1980s and early 1990s (Lacerda 2003). Although gold mining has shifted to different parts of the region, mercury contamination is still present in many soils and rivers as a result of land-use change (Lacerda, Bastos and Almeida 2012). This mercury also contributes to atmospheric pollution.

Waste and human health

The Global Waste Management Outlook indicates that cities generate between 7 and 10 billion tonnes of waste per year, figures that are expected to rise, even double, in lower-income African and Asian cities by 2030 (UNEP 2015). It also estimates that 3 billion people lack access to adequate waste disposal facilities, which poses health risks (infections, exposure to chemicals, dust) and generates environmental impacts (soil and water pollution, GHG emissions). An estimated 15 million people are operating globally as informal recyclers, many of them in dump sites (Binion and Gutberlet 2012). Identified health risks for these workers include exposure to chemical hazards, infections, musculoskeletal damage and poor mental health (Binion and Gutberlet 2012). Working in organized groups, such as recycling cooperatives in developing countries (e.g. Bolivia and Colombia), has helped to reduce the domestic waste flow to landfills and improved the livelihoods of the recyclers (UNEP 2015). A key step towards reducing the environmental and health impacts of domestic waste is to shift from regarding waste as a health and environmental threat to including a resource management perspective, using waste as a source of raw materials (UNEP 2015).

Soil contamination

Soil health is essential for life, food security and the ecosystems services provided by soils. Many chemicals coming from industrial, urban and agricultural sources end up contaminating soils. In most developed countries, the main direct causes of site contamination are industrial and commercial activity. The extent of these sites can vary considerably, from small parcels of land to large industrial facilities or agricultural areas. Governments in the developed world maintain an inventory of contaminated and remediated sites. More than 2.5 million potentially contaminated sites are located in Europe, of which 342,000 are thought to be actually contaminated. About one-third of these have been identified, and more than 50,000 sites had been successfully remediated by 2014 (van Liedekerke *et al.* 2014). In the United States of America, the Superfund National Priorities list includes the sites contaminated with complex hazardous substances and pollutants (1,342 in 2016) that impact soil groundwater or surface water and that pose the greatest potential risks to public health and the environment (United States Environmental Protection Agency 2016). In Canada, more than 23,000 contaminated or suspected sites have been identified (Government of Canada 2017).

Developing countries are undergoing significant industrialization and urbanization. In large urban areas, provision of sanitation and drainage is needed as well as adequate governance so that urban waste is disposed of adequately (FAO and Intergovernmental Technical Panel on Soils [ITPS] 2015). Trace elements contaminate agricultural soil and crops in many Asian countries (Thangavel and Sridevi 2017). In many parts of Latin America intensive use of agricultural inputs contributes to soil contamination (UNEP 2010). In Africa, agrochemicals, mining, spills and improper handling of waste have contaminated soils (Gzik *et al.* 2003; Kneebone and Short 2010). In the Near East and North Africa, soil contamination is primarily the result of oil production and heavy mining.

Soil and human health

The burden of disease of soil-transmitted helminths – a group of parasitic worms including hookworm, ascariasis and trichuriais/whipworm – is substantial, affecting human development and cognitive potential (Bartsch *et al.* 2016). These are generally acquired by walking barefoot on soil that has been contaminated by human faeces. High-intensity hookworm infection commonly affects both children and adults (Bartsch *et al.* 2016).

Land contains many trace elements, which enter the human food chain through the raising of crops and animals. Some are essential for good health (e.g. iodine, iron, selenium and zinc), while others are harmful in large quantities (e.g. arsenic and fluoride) (Oliver and Gregory 2015). Soils in mountainous areas often have reduced levels of iodine, and human populations in such areas can face higher health risks, as they are likely to have reduced access to iodine-rich marine foods. Fertilizers are often contaminated by cadmium, which is not essential to human health and is harmful in high doses (Newbigging, Yan and Le 2015).

Positive effects of healthy soils in human health are related to nature's available benefits to people (FAO 2015d). For example, some valuable antibiotics have been derived from soil microorganisms (Oliver and Gregory 2015).

Food, chemicals and human health

Pesticides (defined here as also including herbicides) have generated an almost universal human exposure to synthetic chemicals, many of which are harmful and even fatal at high doses (Nicolopoulou-Stamati *et al.* 2016). However, there is much uncertainty concerning the health effects of chronic exposure to pesticides at lower doses. While human exposure to some chemicals, such as organochlorines, has reduced in recent years due to regulation, other synthetic compounds have entered the human food chain, such as other pesticides, artificial sweeteners and colorants. The health effects of these substances, whether in isolation or combination, are very difficult to determine for reasons including uncertainty concerning exposure, varying rates and times of the accumulation of these compounds and their release from human tissue, and the lag between exposure and disease. In 1990, the World Health Organization (WHO) estimated an annual 735,000 cases of specific chronic effects linked to pesticides globally (WHO and UNEP 1990), but pesticide use has increased dramatically since then, especially in developing countries where lax regulations and an absence of compliance mechanisms expose millions of farmers and workers to pesticides capable of causing chronic effects that include cancers; reproductive, respiratory, immune and neurological effects; and much more (Watts and Williamson 2015).

There is good evidence from high-income countries that groups occupationally exposed to pesticides, such as farmers, have higher rates of non-Hodgkins lymphoma, attributed to pesticides (Schinasi and Leon 2014). Higher than expected rates of Parkinson's disease have also been related to occupational exposure to pesticides (Liew *et al.* 2014). Other factors that influence health, such as age, undernutrition and impaired immune status, may also interact with the health effects of pesticides, but this issue is currently under-studied. The health effects of chronic pesticide exposures vary considerably on women and men due to their different physiologies. Data on pesticide use (and protection) by women and men in food production are incomplete and inconsistent. Overall, men are less sensitive than women to many pesticides (Hardell 2003; Watts 2007; Watts 2013). Pesticides and breast cancer rates have a strong connection (Watts 2007; Watts 2013) and women are more vulnerable than men to endocrine disruption from pesticides (Howard 2003). On the other hand, men are more sensitive to some (other) pesticides (Alavanja *et al.* 2003).

Food quality can also be impaired through biotic contamination, both microbiological and fungal (Gnonlonfin *et al.* 2013). Mycotoxins, including aflatoxins, can be generated when cereals are damaged by rain, both pre-harvest and through poor storage and are an important cause of liver cancer in many low-income settings (Wild and Gong 2010).

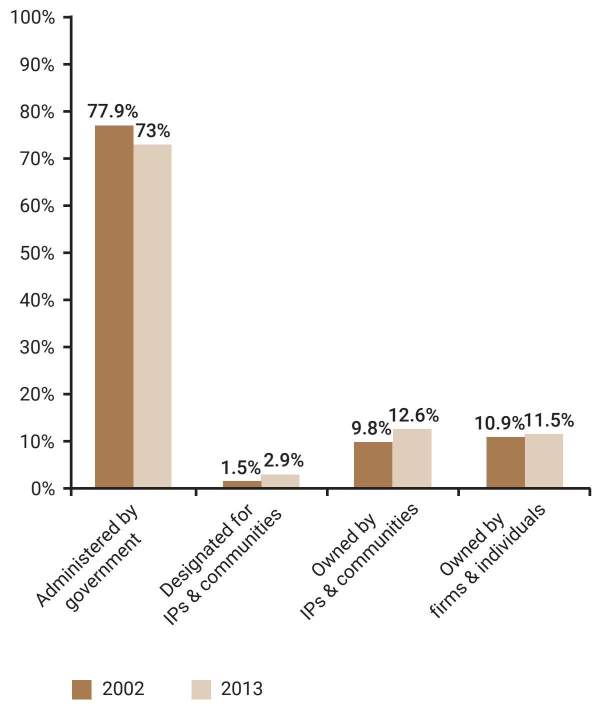
8.5.3 Tenure security

Land tenure, land deals

Despite heavy reliance on land resources, communities, especially in the global South, frequently lack ownership of the land they farm or hold in common. While high-impact scientific studies on the causal linkages between tenure security and food security are lacking (Ghebru and Stein 2013; Holden and Ghebru 2016; Lawry *et al.* 2017), there is sufficient evidence to show that food and energy security of local communities is profoundly diminished when they lose reliable access to their land resources (Godfray *et al.* 2010; Muchomba 2017; Tomei and Ravindranath 2018). Land and housing are the most important assets in large sections of the world. Secure rights, for both men and women, can help turn these assets into economic opportunities (Doss, Kieran and Kilic 2017). It also allows communities to tap into the benefits of institutional support and regulation (Dekker 2016). Indigenous populations, the poor, landless and women are among the most vulnerable to the repercussions of unequal landownership and access (Narh *et al.* 2016).

While the precise amount of community land in the world is unknown, estimates suggest that only approximately 10 per cent of formal land rights are registered or recorded worldwide (Veit and Reytar 2017). Estimates indicate that local communities and indigenous people depend on and manage 50-65 per cent of the world's land area (Alden Wily 2011; Pearce 2016), yet many governments still recognize their rights over only a fraction of these lands (Rights and Resources Initiative [RRI] 2015) **(Figure 8.23)**.

Figure 8.23: Global forest ownership, 2002-2013 (%)



IP: indigenous peoples.
Source: RRI (2015).

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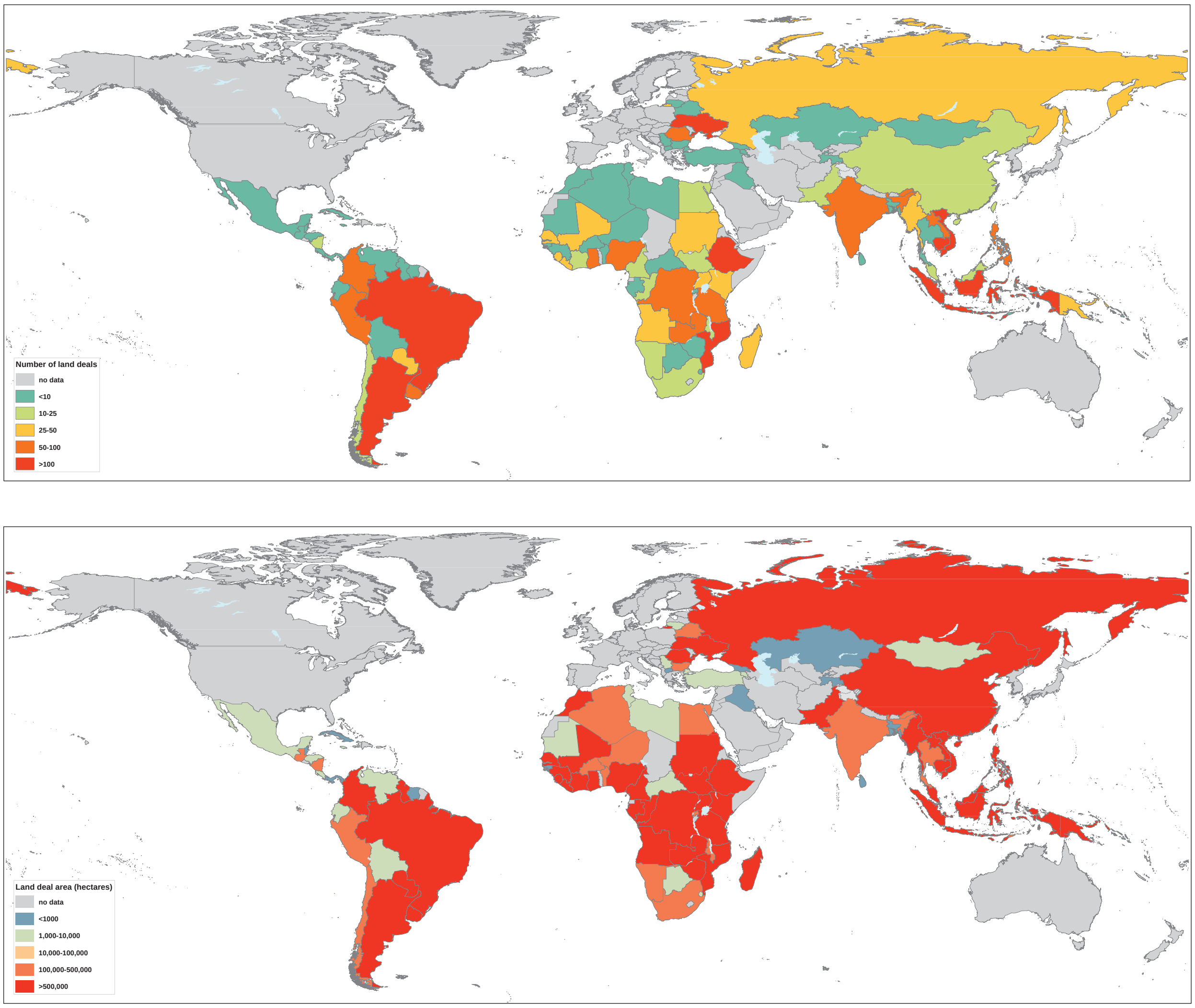
As industrial agriculture and monoculture plantations have expanded, competition for land between industry, governments and communities has increased, putting pressure on forests and drylands, threatening local peoples' livelihoods in some parts of the world (UNCCD 2017). Without formal recognition and protection of their land rights, communities in some countries lack legal recourse following infringement of those rights. In the recent past, stories of poor governance have been under a global spotlight due to issues of land acquisition, land grabbing and land leasing amid fears of food scarcity and rising food prices. Although estimates vary, since 2000, between 26.7 million ha (Nolte, Chamberlain and Giger 2016) and 42 million ha (UNCCD 2017) of agricultural land around the world have become controlled by foreign investors. As of April 2016, Africa remains the most significant target area, with 42 per cent of all deals and 10 million ha (37 per cent) (**Figure 8.24**). Most deals involve the private sector, whose focus is on flexible crops. Importantly, food and biofuels produced on such land are unlikely to reach local communities. Most acquisitions do not include domestic shareholders or local community negotiations, despite often targeting relatively highly populated areas dominated by croplands.

Studies have shown that lack of tenure security among local communities can translate into reduced investments in human capital (Dekker 2016), negative effects on land improvements (Eskander and Barbier 2017), reduced agricultural productivity (Place 2009; Lawry *et al.* 2014) and lower resilience in times of disaster risk (Unger, Zevenbergen and Bennett 2017).

There is increasing evidence of local indigenous communities successfully managing and conserving lands (**Box 8.3**). The World Resources Institute (Ding *et al.* 2016; Veit and Reytar 2017) indicates that 'tenure-secure' indigenous lands generate billions and sometimes trillions of dollars' worth of benefits in the form of clean water, erosion control, carbon sequestration, reduced pollution, and a suite of other local, regional and global ecosystem services (**Figure 8.25**).

Figure 8.24: Global maps of land deals, number of land deals per country (top), land deal area per country (bottom)



Source: Alexandratos and Bruinsma (2012).

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Box 8.3: Cultural values and conservation in Bhutan

Sustainable land management can be promoted by strengthening environment-friendly cultural values and customary institutions. In Bhutan, cultural values play a role in protecting ecosystem services. Mahayana Buddhism places strong significance on the peaceful coexistence of people with nature and the sanctity of life and compassion for others. This explains in large part the high share (71 per cent) of land area under forests in Bhutan and the fact that 25 per cent of Bhutan's population lives within protected areas (Nkonya, Mirzabaev and Von Braun 2016). Many of Bhutan's Buddhist monasteries are located within the forested landscapes of the country.

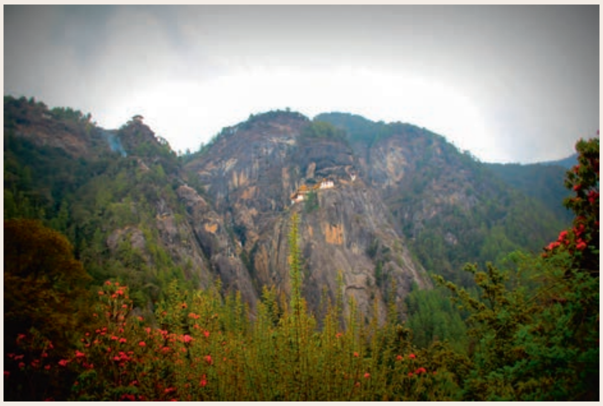

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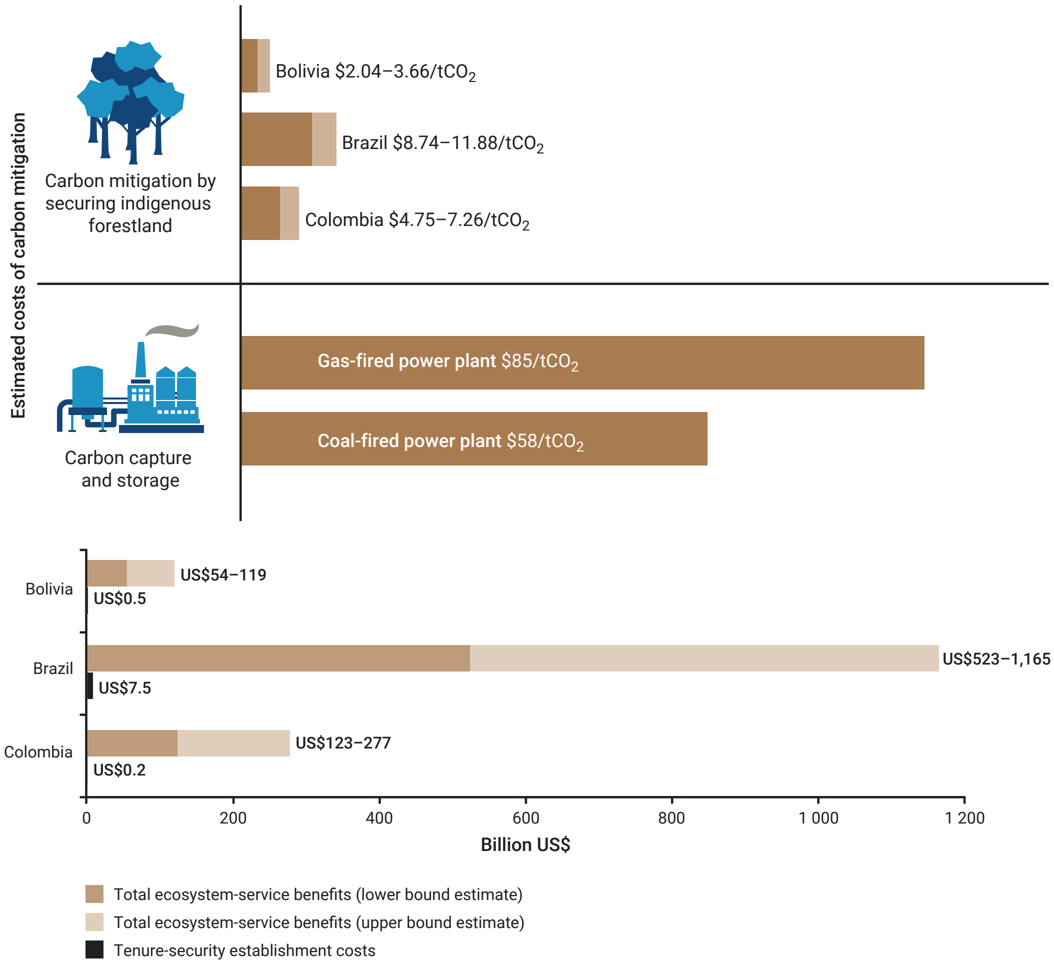
Figure 8.25: Benefits of tenure-secure lands outweigh the costs in three Latin American countries



Source: Ding *et al*. (2016).

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Both the benefits and impacts can, however, vary by region and context due to the complex nature of defining and measuring land tenure. For instance, Eskander and Barbier (2017) find that, in Bangladesh, secure land tenure is associated with improvements in topsoil conservation. However, it is also related to lower human capital investments (e.g. lower spending on educational and recreational activities). Such heterogeneities in findings suggest that adequate attention needs to be given to the broader macro and sector conditions in addition to the local context within which tenure systems are governed.

At a global level, recommendations for stronger land governance in countries that are the targets of large-scale investments are becoming a priority. The rights of indigenous people to their lands and territories are explicitly mentioned in the United Nations Declaration on the Rights of Indigenous People (Article 25 and Article 26) (United Nations 2007).

The FAO *Voluntary Guidelines on the Responsible Governance of Tenure* (VGGT) also seek to improve the governance of land tenure with respect to all forms: public, private communal, indigenous, customary and informal (FAO 2012).

Land and sociocultural services

Land provides a variety of sociocultural and aesthetic benefits to people that are essential for sustainable, healthy livelihoods. Land degradation, deforestation and desertification lead to increases in land abandonment, outmigration and changes in rural power structures (due to increasing demand for intensification), among others. One of the key impacts of these changes has been a loss of critical sociocultural services provided by land, leading to a lowering of overall community resilience (Wilson *et al.* 2016; Wilson *et al*. 2017).

In many developing countries, most people reside in rural areas and are heavily dependent on land resources for their livelihoods. They grow crops for food and to sell in local markets; collect fodder for their livestock; gather wood for their stoves; and collect tree products for their health and well-being (Tomei and Ravindranath 2018). Here, the value of land is often an assertion of their long-standing sociocultural identity, place and heritage (Tomei and Ravindranath 2018). Kelly *et al.* (2015) show that ancient traditions such as festivals related to the preservation of timber, food and fuel resources reveal a deeply embedded relationship between land, culture and identity. In the European Union (EU), the recreational and cultural significance of land is incorporated, to an extent, through national and regional policies on management of ecosystem services. The EU 2020 Biodiversity Strategy, currently being implemented throughout Europe, predominantly covers 'cultural landscapes' (European Commission 2011; Plieninger *et al.* 2013).

Despite progress in recognizing these challenges, land-use trends and impact research continue to be dominated by the study of land-use change from the perspective of productivity, seldom acknowledging and documenting trends in the deep-rooted need for conservation from the perspective of communities (Sharmina *et al.* 2016).

8.5.4 Gender inequality: land, health and food

Existing gender inequality may contribute to increased poverty, people displacement, resource scarcity and other conflicts (Behrman, Meinzen-Dick and Quisumbing 2012; Verma 2014; White, Park and Mi Yong 2015). While progress has been made on the importance of incorporating women to sustain land productivity, it has often been at a superficial level (e.g. to meet certain global targets). Furthermore, women in agrarian societies often have a strategic role in reducing hunger, malnutrition and poverty as they play a central role in household food security, dietary diversity and children's health. Evidence suggests that women are much more likely than men are to spend income from these resources on their children's nutritional and educational needs (Malapit *et al.* 2015; Komatsu, Malapit and Theis 2018).

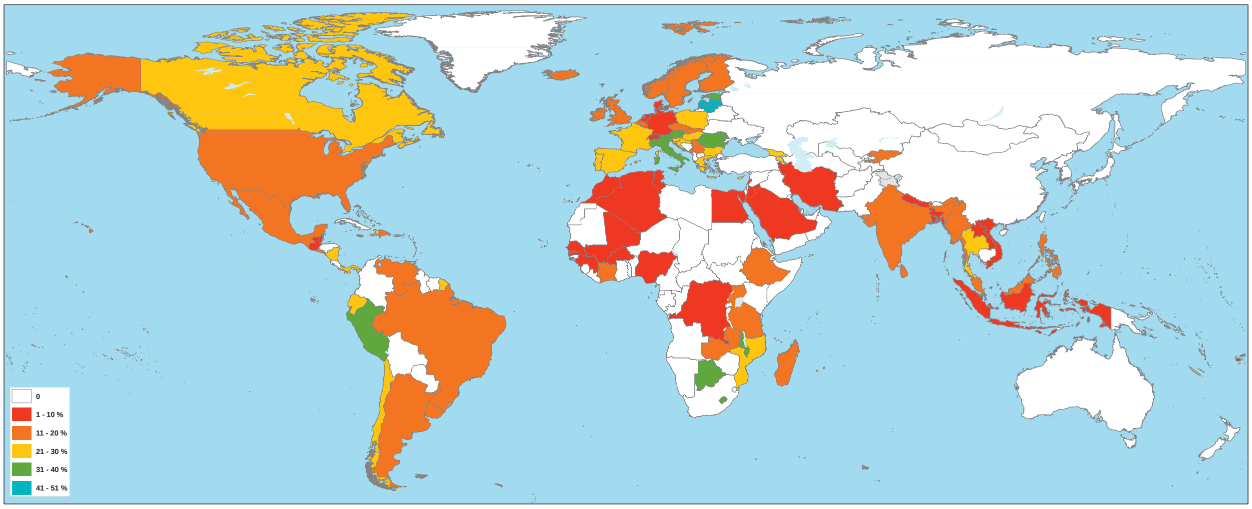
Agricultural contributions by women tend to be underestimated or not considered in official statistics since their focus is usually on formal employment in agriculture and on commercial agriculture. Women are usually engaged in subsistence agriculture, they tend home gardens and collect wild foods, and all these contributions are essential to food security (UNEP 2016a). In 2011, women represented 43 per cent of those economically active in agriculture (FAO 2011). However, they hold titles to less than 20 per cent of agricultural land (FAO 2010). In Africa, only Cape Verde can report that women own over half of agricultural holdings (50.5 per cent) (Doss *et al.* 2017). Few statistics show improvements in land tenure of women during the current decade, especially in countries of the global South (**Figure 8.26**).

Closing the gender gap in access to information and technology, and access to and control over production inputs and land, could increase agricultural productivity and reduce hunger and poverty (Croppenstedt, Goldstein and Rosas 2013).

8.6 Policy responses

Countless policies and actions attempt to address environmental degradation on land. Some strategies have been successful or are promising (e.g. restoration of degraded lands in specific locations such as the Great Green Wall Project in China – see chapter 15, sustainable management strategies such as no-tillage cultivation in Australia, payment for ecosystem services such as Mexico's National Program), while the benefits of others are not necessarily clear (e.g. the expansion of agricultural lands for flexible crop and biofuel production). However, most of these approaches do not consider the variety of benefits people obtain from land and focus only on its productive potential. Globally, land is becoming a scarce resource and is increasingly traded instead of being treated as a global common good due to its importance in the provision of basic services such as food production (Creutzig 2017). This section reviews this undesirable trend, while chapter 15 in Part B discusses in detail alternative land-use policies that could change this unsustainable trajectory.

Figure 8.26: Distribution of agricultural land holdings: females



Source: FAO (2017d).

8.6.1 Economic optimism and land degradation

Land degradation is a key global issue due to its adverse impacts on the environment, agricultural productivity and human welfare. The current paradigm of land management usually considers that the losses caused by land degradation and mismanagement can be compensated by increasing inputs in agriculture, expanding to new areas, and managing lands through command and control strategies such as replacing native forests with plantations (e.g. Chile, Indonesia). This approach also considers that nutritional and other associated social problems will gradually disappear as agricultural production expands (Rosegrant *et al.* 2001). However, social and environmental scientists warn that constantly improving agrotechnology may offer agricultural managers a false sense of security (Eswaran, Lal and Reich 2001).

Current trends are unlikely to supply future demands for food, energy, timber and other ecosystem services taking into consideration even moderate projections for land resources availability. By 2050, demand for food across all categories is likely to be 50 per cent more than today due to dietary changes associated with increasing incomes and population growth (Tilman *et al.* 2011; Alexandratos *et al.* 2012). At the aggregate level, yields are not increasing fast enough to meet demand without significant expansion of the agricultural area (Ray *et al.* 2012; Ray *et al.* 2013; Bajželj *et al.* 2014). This would be difficult to reconcile with large-scale afforestation or deployment of BioEnergy with Carbon Capture and Storage (BECCS) at the levels thought necessary to limit global warming to less than 2°C. For example, Smith *et al.* (2015) estimate that BECCS could require 380-700 million ha by the end of the century, representing up to 14 per cent of global agricultural land, for a 2°C pathway.

Continuing the current track it will be difficult to achieve the land degradation neutrality target adopted at the United Nations Conference on Sustainable Development (Rio+20) in 2012. Land degradation neutrality (LDN) is captured in SDG 15.3. Achieving land degradation neutrality by 2030 is regarded as critical for attaining other key international goals related to reducing biodiversity loss and deforestation, improving human welfare, and climate change adaptation and mitigation. Land-use change, a warmer climate, stagnating yields and unsustainable agricultural practices continue to lead to a reduced stock of organic soil carbon (Wiesmeier *et al.* 2016).

While scientists provide alarming estimates for the decline of productivity of lands globally and regionally due to soil erosion and desertification (Nkonya, Mirzabaev and Von Braun eds. 2016), many economists still believe that if land degradation were a severe issue, market forces would have taken account of it (Utuk and Daniel 2015). In other words, agricultural managers would not let their lands degrade to the point that it affects their incomes (Wiebe 2003). Cumulative productivity losses due to land degradation appear economically acceptable for most agricultural actors. In many instances, farmers can rely on government agricultural policies (e.g. subsidies for inputs and machinery) to curb losses associated with land degradation (Jat, Sahrawat and Kassam 2013).

However, these policies are not sustainable in either developing or developed countries. Market fluctuations of agricultural inputs could be more volatile than output prices. From 2005 to 2008, fertilizer prices rose much faster (by 400 per cent) than maize prices (by 100 per cent) and reached record high levels in 2008. In this case an input subsidy would be inefficient as

8

it would encourage unprofitable use of inputs (**Figure 8.27**) (Baltzer and Hansen 2011). The same study indicates that, in Malawi, the subsidy ratio jumped from 79 per cent to 91 per cent or from 3.4 per cent to 6.6 per cent of GDP in 2008-2009.

In sub-Saharan Africa (SSA), the contribution of fertilizer subsidies to national food security strategies remains highly controversial (Druilhe and Barreiro-Hurlé 2012). Success in the Asian Green Revolution was based on two main food crops grown under irrigation, wheat and rice. In SSA countries, yield response to fertilizer application is observed for some crops (e.g. maize), but not for most other staple crops grown in rain-fed areas (e.g. cassava, plantain, yam). In these contexts, fertilizer use is not profitable under market conditions, especially in some remote areas where output prices are too low. In order to be effective, agricultural programmes should be complemented with other government investments in infrastructure, education, health and rural development (Druilhe and Barreiro-Hurlé 2012) (**Figure 8.28**).

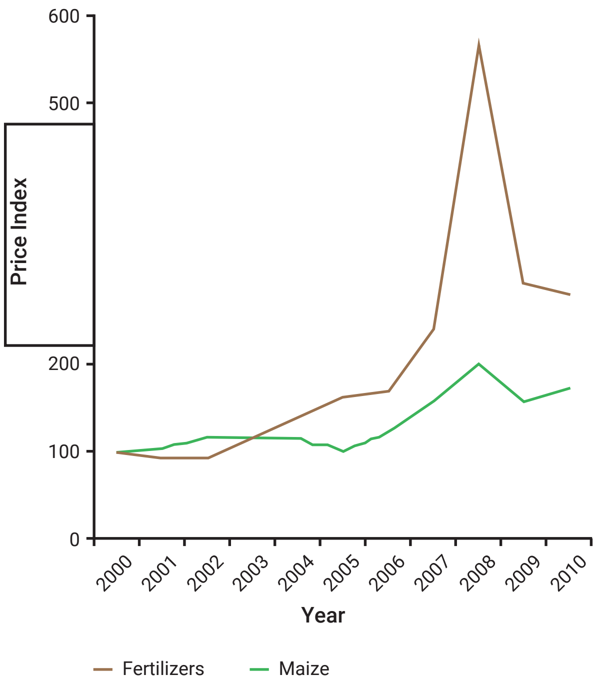
Reducing farm subsidies in rich countries would be positive for poor countries, although the effect will depend on their economic, trade and poverty characteristics (Boysen, Jensen and Matthews 2016). Meanwhile, the availability of subsidies in rich countries does not provide an incentive to adopt innovative soil conservation strategies.

For a long time, the market price of crops has been the standard for determining land-use policy. However, a new trend is being observed in growing competition between the financial and economic values of land. Land speculation and land grabbing can distort the actual economic value generated by land. With increasing land scarcity, the trend to consider land as a 'commodity' is only strengthened (ELD 2013). As land prices increase, more farmland will be sold to outsiders purely for speculative purposes. Consequently, lands might be left idle for some time, leading to less agricultural production, exacting a significant social cost if the practice becomes widespread.

In the EU, inflationary pressures are fueling land speculation and the acquisition of farmland. This rapid inflation has been attributed to the rise of 'new investors' in farmland, some with little connection to agriculture or farming. This process has been termed by French activists as one of 'land artificialization': the loss of prime agricultural land, the expansion of cities, urban development, tourism and other commercial undertakings (Borras, Franco and van der Ploeg 2013). Land speculation and land 'artificialization' contribute to farmland concentration in the EU by raising the stakes and increasing the barriers for prospective farmers to take up farming (Kay, Peuch and Franco 2015).

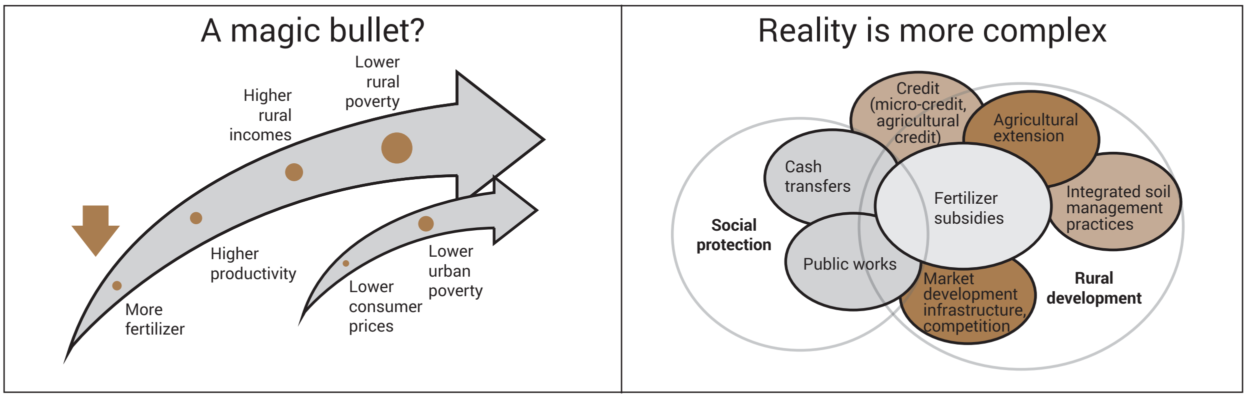
One of the indicators of ever-increasing commoditization and commercialization of land was a recent boom for biofuel production. The relative abundance of cheap and suitable land in poor countries and increasingly liberalized trade and

Figure 8.27: Fertilizer and maize prices, 2000-2010



Prices are real US$ indices of world market prices.
Source: Baltzer and Hansen (2011).

Figure 8.28: Where should subsidies fit?



Source: Druilhe and Barreiro-Hurlé (2012).

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investment regimes made them an attractive destination for farmland investments for biofuels (Schoneveld and German 2014). According to some experts, a boom of biofuel production was an important factor in the global food crisis in 2007-2008 (Chakrabortty 2008).

8.6.2 Challenges for achieving the SDGs

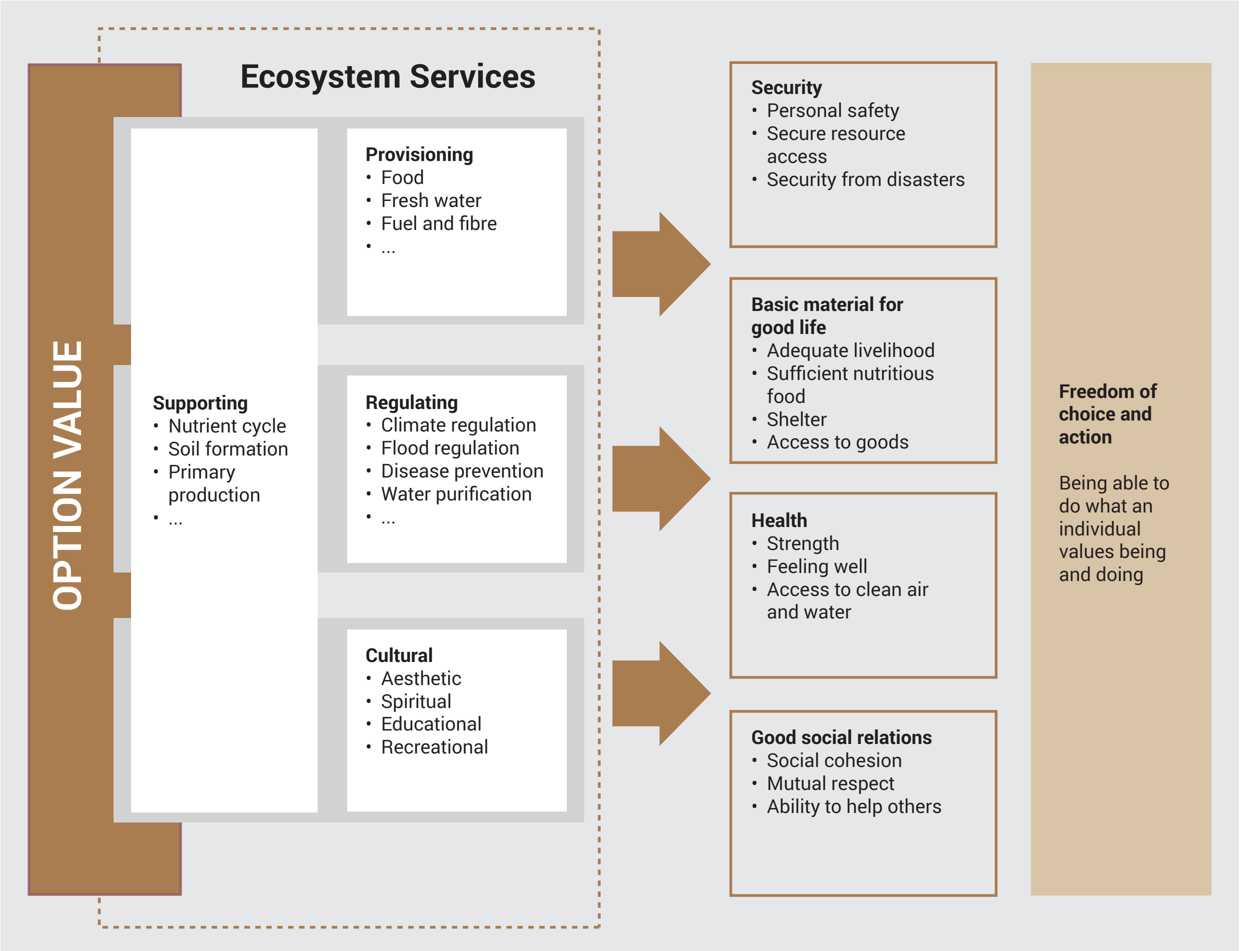
Estimating the full economic benefits of land is neither easy nor straightforward (UNEP 2016b). The ecosystem services framework can contribute to comprehensive ecosystem assessments by dividing ecosystem services provided by land into categories that are interdependent and can be valued separately (**Figure 8.29**).

Current land management cannot prevent loss of natural capital while preserving ecosystem services (e.g. moisture retention, nutrient cycling), combating climate change (e.g. carbon sequestration), providing sustainable food production, addressing energy and water security, and promoting fair access to land (ELD 2013).

Intergenerational equity is not necessarily considered in current land management strategies, and present productivity gains are valued more than sustainable production for the future. Furthermore, land-use policy may not reflect the teleconnections that link production and consumption across the globe. According to current land policy approaches, most issues which cannot be addressed by increasing inputs are automatically dropped outside the land-policy domain. However, this approach is inappropriate as many social, gender, poverty and health issues are directly or indirectly associated with conventional ways of managing land resources and trading them across the globe.

Economic optimism plays in favour of enlarging farms due to their economic effectiveness and the difficulty of incorporating the economic impacts of the degradation of land resources. However, maximizing smallholders' potential, including women and indigenous peoples, is essential for food security and proper nutrition, and for reaching many SDGs. There are about 570 million farms in the world, and 84 per cent operate on less than 2 ha of land (International Food Policy Research Institute

Figure 8.29: The provision of ecosystem services from natural capital: linkages between ecosystem services and human well-being



Source: Millennium Ecosystem Asessment (2003).

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[IFPRI] 2016). Small farms play different roles: billions of people get their income, employment and food from these lands. They are also home to most of the world's undernourished population. FAO estimates that if gender inequality in access to land resources is eliminated, agricultural output could increase by 2.5-4.0 per cent. Additionally, it would lead to a reduction of 12-17 per cent reduction in the number of undernourished people in developing countries (IFPRI 2016). In low-income agrarian societies, agricultural growth is more effective for reducing hunger and poverty than promoting any other sector of the economy (FAO 2015e). If SDG Target 2.3 is to be achieved by 2030, agricultural productivity of small farms should increase simultaneously with the incomes of their farmers. Policies should especially target the most vulnerable small-scale food producers (e.g. women, indigenous peoples), so they can have guaranteed access to market and other production means, including their material, informational and financial needs.

It is clear that minimizing food losses and waste will have significant environmental, social and economic benefits in supporting global food security (UNEP 2015). Where waste cannot be prevented, opportunities to recover value, such as conversion to compost, liquid fertilizers, biogas or higher value end-use products such as animal feed protein or biochemicals, should be explored (Jayathilakan *et al.* 2012; Nguyen, Tomberlin and Vanlaerhoven 2015; UNEP 2015). Achieving SDG Target 12.3 of halving per capita global food losses and waste at the retail and consumer levels and reducing food losses along production and supply chains, including post-harvest losses, by 2030, will require significant intervention and commitment, but also diverse strategies, since the reasons for food losses and waste, and the area within the food supply chain where losses and waste occur, differ between developed and developing countries (FAO 2015c).

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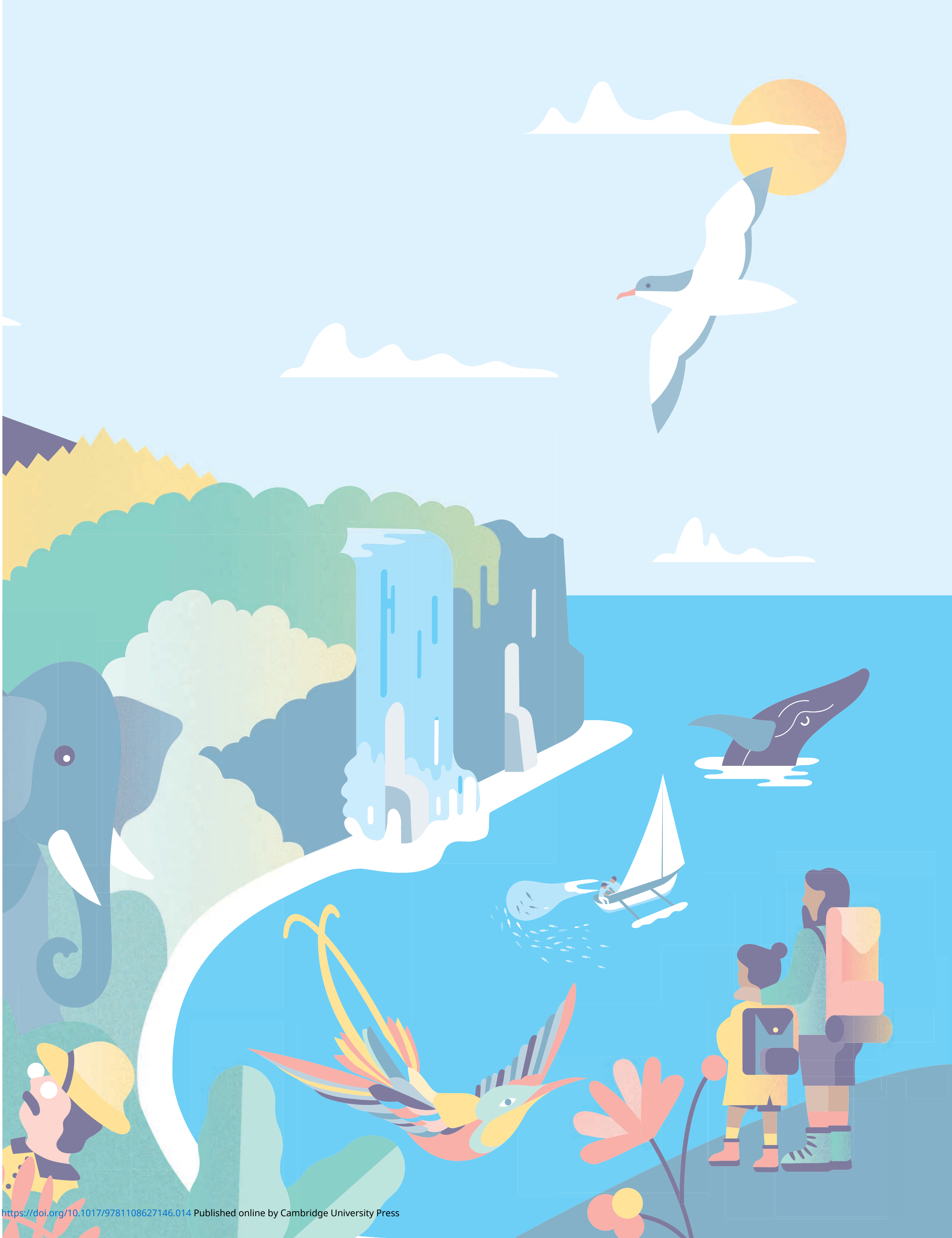

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