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Land Use and Food Security in 2050: a Narrow Road

Agrimonde-Terra

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5. Retrospective Overview of Land Uses at Global Level and by World Regions

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Introduction

THE FORESIGHT PROCESS INTEGRATES THE LONG-TERM DIMENSION, past and future. In this chapter we concentrate on the past dimension and present a rapid review of the evolution of the five dimensions of land use between 1960 and the early 2010s, at both a global level and for six world regions. Describing past trends and breaks in the five dimensions of land use helps to grasp their long-term dynamics as well as the roots of the current situation in land use and food security.

As presented in Chapter 1, Agrimonde-Terra considers that there are five complementary, interlinked and dynamic dimensions of land use. The land's agronomic potential is the first dimension and determines the suitability of land for agriculture and, within agriculture, for different crops. Land's agronomic potential varies over time as a result of climate change, farmers' decisions and technical progress, as well as policies through their impacts on these drivers. Access to land is the second dimension. It depends on land tenure systems and land policy, which are affected by the geopolitical situation, the degree of competition for land, farmers' incomes and access to credit etc. A qualitative analysis of the evolution of access to land can be provided. The distribution of land between different uses is the third dimension. Diets, demography, climate, and international trade are important drivers of this dimension. The fourth dimension is the degree of intensity of land use. It evolves over time as it is influenced by available techniques (*e.g.*, technical progress) and farmers' decisions. The final dimension of land use is the services land provides. These services depend on how land is used (agriculture *vs.* forests, for instance) and, as

20. Marco Barzman prepared a retrospective of land use in OECD countries and in Latin America and the Caribbean (LAC). Pauline Marty prepared a retrospective of land use in Former Soviet Union (FSU) and in Middle East and North Africa (MENA). Clémence Moreau prepared a retrospective of land use in Asia and in sub-Saharan Africa (SSA).

21. The authors thank Chantal Le Mouël for all her suggestions and proofreading of this chapter.

far as agricultural land is concerned, on farming practices. This dimension of land use focuses on the linkages between ecosystems and human well-being, and has grown in importance since the 1990s.

Most of the data used in this chapter are from FAOStat. Data on land use thus use the FAO classification.[22]

The agronomic potential of land

In recent decades, and in all regions of the world, the agronomic potential of land, *i.e.* its suitability for cultivation, has been, in some places, positively influenced by agricultural practices that have restored soil nutrients, improved soil organic matter and soil biotic activity, protected soils from strong winds and erosive water flows, enhanced biological interactions and synergies (UNEP, 2014). However, in most places of the world, the agronomic potential of land has been negatively affected by land-management activities such as mechanized agriculture, monoculture practices, inappropriate use of inputs and overgrazing, as well as by urban and industrial expansion and mining activities (UNEP/UNECE, 2016). Other on-going trends are the impacts of natural factors, such as floods, landslides and land sealing, and extreme climate events on the agronomic potential of land (UNEP/UNECE, 2016). Water reserves are also depleting in a number of regions. Millions of households are located in areas where the agronomic potential of land and water reserves are in decline and this has a major impact on their food security. Scherr (1999) estimates that about one fourth of the global soils and 38% of arable land and permanent crops area are degraded. Of a total of around 1,900 million hectares of degraded land, around 1,200 hectares is estimated to be 'seriously degraded', and persistently high rates of erosion affect more than 1,100 million hectares of land worldwide (Lavelle *et al.*, 2005, cited by UNEP, 2014).

The past and current agronomic potential of land in the various regions of the world differ widely according to their land endowment, to human activities and natural events. Figure 5.1 presents the observed land use (arable land, pasture, forest and others; Box 5.1 for a glossary of terms on land use) and maximum cultivable area (*i.e.*, GAEZ 1 to 4, Chapter 4) in 2010.[23] North Africa, the Near and Middle East, China, India and West Africa have the lowest areas of land suitable for crop production. Arable and permanent crops areas in North Africa, the Near and Middle East and China are about to reach or already exceed areas considered suitable for cultivation which means that arable and permanent

22. For more details on classification and available data in FAOStat, see http://faostat3.fao.org/. Data series in some regions (especially FSU, MENA, Asia and SSA) are not always reliable.

23. As presented in Chapter 4, land with a suitability index greater than 40% has been considered as suitable land for crop production and considered as the maximum cultivable land area for regions whose cultivated land area in 2010 does not exceed this assumed maximum cultivable land area.

Box 5.1. Glossary of terms used relative to land use.

Agricultural area: sum of areas under "Arable land and Permanent crops" and "Permanent meadows and pastures".

Arable land: land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for "Arable land" are not meant to indicate the amount of land that is potentially cultivable.

Forest area: land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10%, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use.

Permanent crops: land cultivated with long-term crops which do not have to be replanted for several years (such as cocoa and coffee); land under trees and shrubs producing flowers, such as roses and jasmine; and nurseries (except those for forest trees, which should be classified under "forest"). Permanent meadows and pastures are excluded from land under permanent crops.

Other land: land not classified as Agricultural land and Forest area. It includes built-up and related land, barren land, other wooded land etc.

Permanent meadows and pastures: land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).

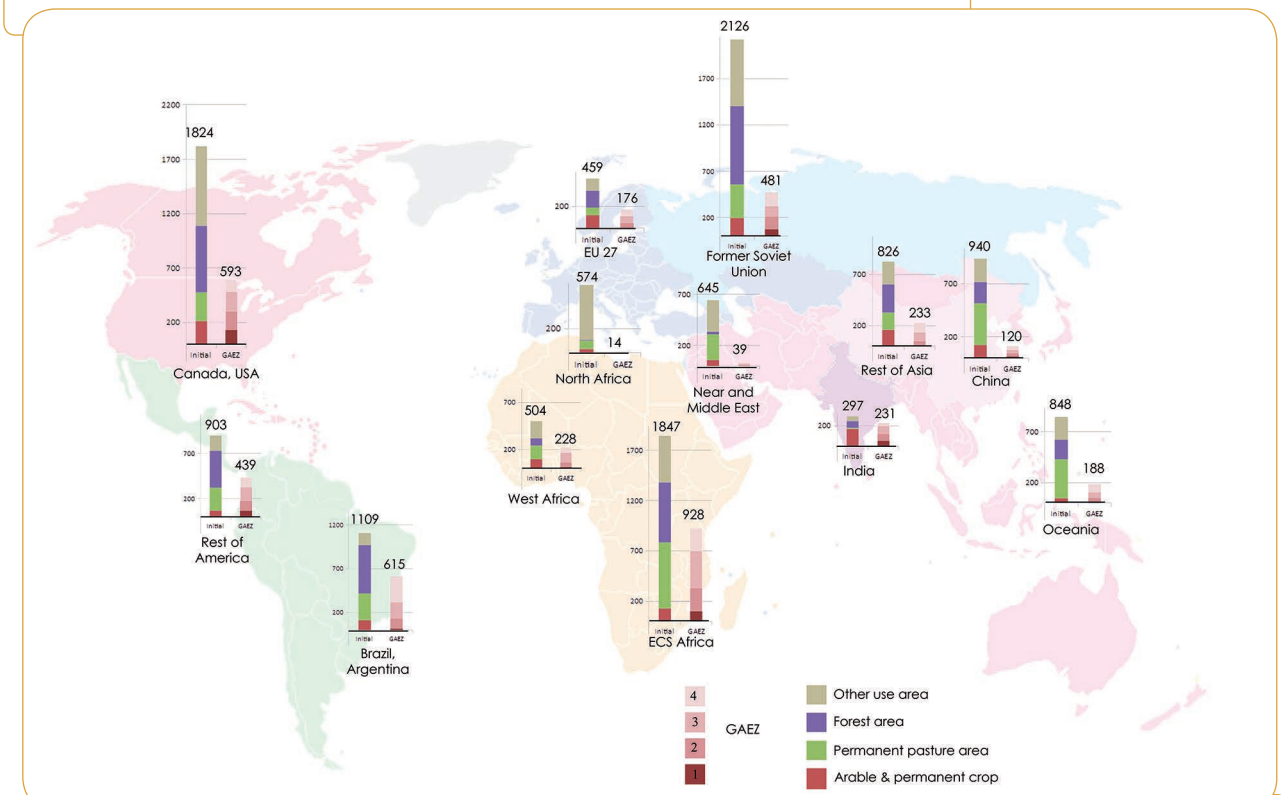
Agrimonde-Terra uses the term "**Cultivated area**" to designate arable land + permanent crops.

Source: FAO statistics division - Food and Agriculture Organization of the United Nations, Last updated April 2014.

crops are already planted on land where potentially attainable yields are considered relatively low. In India, arable and permanent crop areas are close to the 231 million hectares considered suitable for crop production. In highly densely populated countries of sub-Saharan Africa (SSA), such as Rwanda and Burundi, the maximum cultivable area has also been reached. In large regions such as Canada/USA, Latin America, East, Central and South (ECS) Africa and the Former Soviet Union (FSU), there are still vast areas suitable for crop production. These areas however may be currently devoted to other usages such as forests or infrastructure, for instance, and thus not directly available for agriculture (*e.g.*, Lambin and Meyfroidt, 2011). The largest cultivable areas are found in ECS Africa (928 million hectares), followed by Brazil and Argentina (615 million hectares), and Canada and USA (593 million hectares).

The Latin America and Caribbean region (LAC) is rich in natural resources and more than 52% of its total area has a good agronomic potential (GAEZ 1 to 4). However, degradation is one of the greatest challenges in the region and all countries are affected by one or more processes of soil, water and air contamination in at least part of their territory

Figure 5.1. World map of Agrimonde-Terra regions with observed land use (arable land, pasture, forest and others) and maximum cultivable area in 2010 (million ha).



Source: GlobAgri-AgT, adapted data from FAOStat (http://faostat3.fao.org/) and GAEZ project (http://www.fao.org/nr/gaez/fr/). Graphic design: Elodie Carl.

(UNEP-lac, 2016). This deterioration is caused by deforestation and excessive grazing, over-exploitation of the soil due to monoculture practices, failure to rotate crops, and improper intensive irrigation. The development of infrastructure, urbanization, mining and oil exploitation are also affecting the areas suitable for agriculture. The pressures on water differ vastly within the sub-regions, but agricultural, industrial and household demand for water resources increases with population growth, economic development and frequency of extreme climatic events (UNEP-lac, 2016). The region has started to reforest, but plantations are mostly on land no longer suitable for agriculture, either because of land degradation or because of the costs required for transforming them into areas suitable for new agricultural production systems (UNEP-lac, 2016).

In North Africa, land with a good agronomic potential represents only 2% of the total area. In West and ECS Africa, land with a good agronomic potential represents between 45 and 50% of the total area respectively. In many countries of North and sub-Saharan Africa, because of the small area with good agronomic potential, farmers cultivate or graze their animals on environmentally fragile areas without appropriate conservation measures, poor fertilizer management and inefficient irrigation practices. This leads to degradation, especially loss of top soil, salinization and desertification (UNEP-africa, 2016). The most severe land degradation has occurred on grasslands (40% are degraded), forestland (about 26% are degraded) and cropland (12% degraded) (Nkonya *et al.*, 2016). In SSA, it is estimated that land degradation affects up to two-thirds of the productive land area and 65% of the entire African population (ELD Initiative and UNEP, 2015). Natural factors, such as climate variability and extreme climate events, wind and water erosion, play a major role in land degradation. Demand for agricultural products and fuelwood, inappropriate cultivation practices, commercial logging, urbanization, mining activities and industrialization are also affecting the agronomic potential (Rudel, 2013).

In Asia, about 28% of the total area has a good agronomic potential. However, this is an average hiding high variability across Asian countries; corresponding figures are 70% for India and only 12% for China. Over past decades, the agronomic potential of land and water reserves have been significantly depleted by agricultural intensification, urbanization, and development of infrastructure, demand for biofuels, mining and industrial activities (UNEP-asia, 2016). Over-application of chemical fertilizers, irrigation at a large scale and with poor drainage, rapid crop rotation and overgrazing have led to soil pollution (including pollution by heavy metals), erosion, compaction, acidification, salinization, declining soil organic matter, weed infestation, soil fertility depletion, and biological degradation, which need urgent attention according to UNEP (UNEP-asia, 2016).

In Europe, North America and the Former Soviet Union, the area with good agronomic potential represents about 28% in average of the total area. The land is affected by farming and land-management practices, urbanization, especially the creation of urban-rural 'fringe' areas, and the development of infrastructure and recreation areas. This is leading to soil erosion and loss of organic matter, but also to soil contamination, loss of biodiversity, compaction and other physical deterioration, salinization, floods, landslides

and land sealing (UNEP/UNECE, 2016). There are sub-regional differences: land sealing is prevalent in Western Europe, and land abandonment is prevalent in Eastern Europe and FSU. Climate change could accelerate the intensity of these threats to soil quality.

In the future, the above-mentioned events could continue to negatively impact the agronomic potential of land and agricultural productivity unless there are radical changes in policies and practices. In addition, future climate change will affect the agronomic potential of land all over the planet (Chapter 7).

Access to land

ACCESS TO LAND IS A MAJOR DIMENSION OF LAND USE and poor access to land, either in the form of landlessness or because of insecure and contested land rights, often leads to rural poverty and food insecurity (Cotula *et al.*, 2006). In many countries, a wide array of overlapping, and at times contradictory, rules, laws, customs, traditions, perceptions and regulations that govern access, use, control and transfer of land, are found (IFAD, 2008). Therefore, farmers have various means of access to land. The main paths are intra-family transfers, community membership, land markets for purchases and leases, and land reforms and programmes by States or decentralized institutions and groups (*e.g.*, land registration, redistribution of land, restitution and recognition of land rights) (de Janvry *et al.*, 2001). This means that access to land does not only have a legal dimension, but it also has a social, cultural and demographic dimension, a political dimension and an economic dimension. The expansion of a classic understanding of property rights that results in a market for land rights is therefore only one of the means to improve access to land (de Schutter, 2011). Lack of access to land can result in poverty, exclusion and food insecurity, especially when access to other economic activities is difficult.

In most countries of Africa, Asia, Latin America and the Caribbean, land tenure systems have been influenced by colonial patterns. During the colonial period, to secure economic advantages from their possessions, the colonial agents took the richest natural resources for themselves and paid little attention to local people. Several land tenure systems co-existed: the system of the colonial power, customary rights to land set by traditional authorities who determined who used land, and areas without control of any authorities (Rudel and Hernandez, 2017). After independence, each country set up agrarian reforms in its own way. Some countries produced State-secured land tenure systems, but others did not manage to do so.

Over the past 40 years, access to land in Latin America and the Caribbean has remained mostly inequitable and insecure, despite efforts to reform aspects of property rights, to regularize land registration of rural and urban land and to modernize land registration systems. The colonization process led to the establishment of immense estates and the fact that there is often hardly any limit to the exclusive character of private property (Merlet, 2010). Extensive land reforms started in the 1910s in Mexico, and agrarian reforms

and redistribution programmes took place in a number of other countries as an outcome of revolutions and changes in policies to redress the dualistic latifundias-minifundias land tenure structure. Some of the land in the haciendas was expropriated; access to land and, later, land titles, were given to former permanent workers of these estates. Modernization projects targeting traditional structures were set up. Starting in the 1970s, and mostly in the 1990s, Latin American governments, often encouraged by the United States, reoriented their agrarian policies and enacted laws which encouraged the land market as a solution to the agricultural problem. Today, the land tenure systems have led to three pathways: the subdivision of farms, which is found in Mexico, Central America and the Andean nations, the concentration and foreignization of land in the Southern Cone countries, and the pre-eminence of State land ownership in the Caribbean (ECLAC-FAO-IICA, 2013). Land tenure in frontier regions remains highly contested (Borras *et al.*, 2011) and unequal. This situation leads to land conflicts, as multiple actors compete for the same land (UNEP-lac, 2016). About 80% of the total arable land is in farms of more than 100 hectares and this land is frequently under-used or left idle; 2% of the land is controlled by 50% of the smallest and subsistence farms which overuse it (ECLAC-FAO-IICA, 2013; Lowder *et al.*, 2016). In the past decade, land grabbing has been an important issue, especially in Argentina and Brazil. In many cases, it results in the incorporation, mostly adversely, of smallholders and indigenous communities into the emerging plantations and value chains (FAO, 2014). Peasants may retain some access to land but lose their control over activities and are forced to diversify their sources of income. Therefore, important tensions between landless farmers and very smallholders on the one hand, and large landowners on the other, still remain. Finally, it is important to note that in Latin America, concomitantly, actions have been taken to facilitate the ownership and control of land by indigenous peoples and local communities. They now own 18% of the land and control an additional 5%, which is high compared to the global situation, where they own 10% of land and control an additional 8% (Rights and Resources Initiative, 2015).

After independence, most Asian countries implemented land reform programmes. Socialist reforms were implemented by revolutionary governments in China and Vietnam, and later followed by de-collectivisation. Land reforms were implemented in Japan, South Korea and Taiwan and considered successful. In India, land reforms are carried out at the sub-national State level and therefore security of access to land, paths to land market liberalization and land provision for specific private players differ from one sub-national State to the other (Sud, 2014). In other Asian countries, trends were towards land markets. Over the years, rapid population growth and high population density created pressures on land and access to land for small farmers became increasingly difficult. There was some rethinking of the role and functions of the central state, greater decentralization, and peasant movements and civil society organizations became more influential. Today, access to land is still insecure because of the unfinished agenda of land reforms, especially land reforms for forests and the 'public domain' which have been neglected (Quizon, 2013). Agriculture is dominated by smallholders who depend largely on household labour and have less than two hectares of cropland; pressure on land is very high. Nevertheless, this does not prevent

large-scale acquisitions or leasing of lands by corporations, leading to the displacement of small farmers, settlers and indigenous communities. According to Land Matrix data, 305 large-scale deals involving 4.9 million hectares have been concluded in Asia (mostly Cambodia, Laos, Indonesia and the Philippines) since 2000 (Nolte *et al.,* 2016). A number of South-East Asian investors, notably Malaysian companies, but also companies in Singapore, India, Hong Kong and China, which have high population pressures, are also engaging in major land deals and accessing land at the expense of smallholders. Leaving aside China, which has recognized a significant portion of its land as community-owned, indigenous peoples and local communities formally own less than 1% of the land in Asia.

In Africa, secure, equal and equitable access to land is also a major issue. The concept of 'State-owned land' is of particular importance and covers a wide range of situations (Chouquer, 2011). It is usually accompanied by a system of concessions or use rights, which regulate the way that the State makes land available for use by others and plays an important role in the current search for land by corporations. As far as access to land by women is concerned, "the pattern that women own less land than men, regardless of how ownership is conceptualized, is remarkably consistent", and in many cases, the gender gaps are quite large (Doss *et al.,* 2013, p. 29). Access to land for most African women is "still linked to their relationship with a male family member and is forfeited if the relationship ends" (Al-Zubaidi and Assubuji, 2013, p. 5).

In North Africa, a number of countries (for example, Algeria, Egypt, Libya and Tunisia) have undertaken extensive land reform programmes but land rights often remain extremely complex and include registered lands, melk lands (private lands), habous lands (or waqf) and customary forms of pastoral land management (AUC-ECA-AfDB Consortium, 2010). The consequence is persisting land tenure insecurity and conflicts. In some countries, a dual form of agriculture is found with large properties and public domains on the one hand, and very small plots cultivated for subsistence by family farmers on the other hand. Women's rights over land are very poorly recognized.

After independence in sub-Saharan Africa, a variety of land administrative reforms were introduced reflecting different types of national coalitions and alliances. During the structural adjustment programmes, land reforms became subject to two countervailing pressures: the promotion of land markets as well as the promotion of private land rights, which required convertibility of customary rights into statutory tenure, decentralizing administration, giving greater roles to civil society and communities, and establishing policies that protect the livelihood interests of the poor (Amanor, 2012). Support to local institutions to undertake intermediate forms of land registration has been effective in a number of places, with careful checks of local and external interests, measures to limit disputes and to ensure that the needs of those with the least power are given due weight (Toulmin, 2009). Nevertheless, access to land is still the cause of many conflicts between farmers and herders, local populations and migrants, local populations and corporations, as well as displacements. Tensions are particularly high when the agronomic potential is high because of access to water, as well as when population densities are

high. Purchases and leases of land by local urban and foreign investors are increasing the pressures on local and small farmers. According to Land Matrix data, Africa is by far the most targeted continent by foreign investors. Since 2000, 422 agricultural deals were concluded involving a total area of almost 10 million hectares; they are mostly located along the major rivers (Nolte *et al.,* 2016).

In FSU, access to land is still marked by the collectivization period despite the collapse of Soviet Union in 1991. The land reform of the early 1990s was extremely rapid. In theory, the state monopoly on land was repudiated and the ownership of agricultural land was transferred free of charge from the State to private individuals and collective farms, and required farms to reorganize as joint-stock companies. In addition to peasants, the land was to be distributed to any other qualified individuals who requested it and intended to use it for agricultural purposes. However, in practice, the process of establishing land property and rights has been slow, incomplete and variable from country to country. This is favouring the purchasing and leasing of land by foreigners; Ukraine and Russia are second and third in terms of target countries for foreign investments in land (Nolte *et al.,* 2016).

In OECD countries, land tenure is considered secure. The French Civil Code, British Common Law, and the German-style land book, all contribute to securing land access and transferability of rights. From a legal point of view, access to land by men and women is possible. From an economic point of view, younger people find it increasingly difficult to access, and some countries have set up systems to facilitate their access to land. Nevertheless, there is an increase in the degree of foreign ownership of farmland. This is especially noticeable in some parts of Spain and Eastern and Central Europe. Small farmers are being thrown out of farming every year while large farms and agribusinesses are expanding their scope widely and rapidly. For example, in Romania, 0.4% of farms exploit 49% of the agricultural area (Levesque, 2014). In Australia, about 9.78% of the cultivated area is considered 'grabbed' (Rulli *et al.,* 2013). In a number of OECD countries, land sealing (*e.g.*, infrastructural development and urban sprawl) is limiting the development of agricultural areas and contributing to higher value for land.

Finally, land has always been a basic repository of wealth and value. For producers, farmland generates income through production. For investors, income is generated either through lease payments collected from tenant farmers, or as a percentage of harvest revenues. Over the past decade, farmland valuations have increased in the USA, Brazil and Australia.[24] Investment in farmland has switched from an asset class limited to farmers, wealthy individuals and a few financial institutions to a sought-after asset class that provides good returns on investments. According to Nolte *et al.* (2016), investors target two groups of countries. The first group consists of countries with a high Global Hunger Index (GHI) and a high dependence on their agricultural sectors. Their presence in these countries is supposed to lead to higher food production and job creation. The second group consists of countries with a much lower GHI and agriculture is proportionally less

24. http://www.informaecon.com/MCSGlobalFarmSurveyJul2014.pdf

important to their national economies. Acquisitions take place in the context of a transition from centrally planned state economies to more capitalist and free market economies. In South America, the State is rarely involved as an intermediary.

This very brief description demonstrates that in many regions of the world, access to land is still insecure, unequal and inequitable. Many States do not have tenure systems which can prevent the concentration and foreignization of land. There are tensions between processes of decentralization of the administration of land tenure and political centralization, use and access to national land, land markets and fiscal resources. Also, there are a growing number of contracts (concessions) between States and investors. The value of land has increased and buying land is increasingly considered as a good investment by companies and individuals. However, small farmers are starting to develop a variety of strategies to adapt.

Distribution of land between different uses

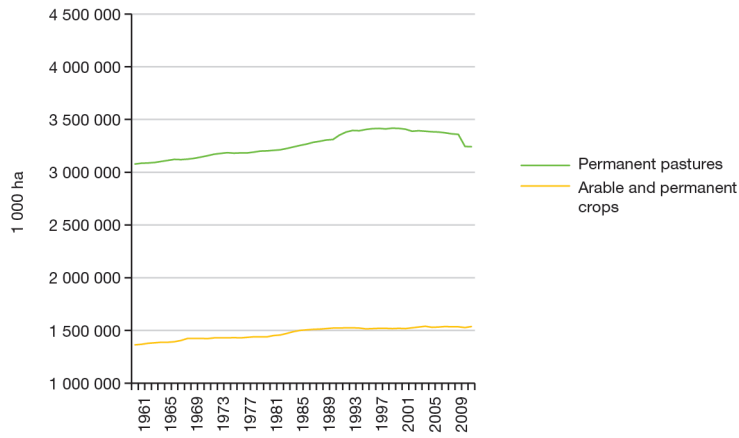
Global overview

Since the 16th century, the total global area of permanent cropland has almost doubled every century from 300 million hectares around 1700, to 420 million hectares around 1800, to 850 million hectares around 1900 and to 15,300 million hectares around 2000 (Klein Goldewijk *et al.,* 2011). In 2010, cropland comprises about 10% (around 1,500 million hectares) of the world land area, whereas agricultural area in total made up around 33% (around 4,900 million hectares). Between 1961 and 2010, world arable and permanent crops areas have increased by about +12% (from 1,368 million hectares to 1,527 million hectares) (Figure 5.2). This net increase is the result of an area of land newly brought into cultivation that is greater than the area of land which came out of production during the same period. During this period, the global irrigated area has doubled, accounting for most of the net increase in cultivated land, and land under rainfed systems have shown a very slight decline (FAO, 2011b).

Between 1961 and 2010, within harvested areas (Box 5.1) of arable and permanent crops, the share of the area dedicated to cereals shrunk from 67% to 55% and that of oil crops rose from 8% to 18% (Figure 5.3). However, there was an expansion of the area for the major cereals (maize, rice and wheat) between 1965 and 1982, stagnation until 2002, and a decrease since then (Figure 5.4 and Grassini *et al.,* 2013). Overall, the share of the major cereals in world harvested areas of arable and permanent crops decreased slightly from 44% in 1961 to 42% in 2010. Oil crops, especially soyabean, have expanded rapidly since the early 2000s (Figure 5.5). Globally, the share of the area dedicated to fruit and vegetables increased from 5% to 8%, that of pulses fell from 7% to 6%, while that of roots and tubers as well as fibres fell from 5% to 4%. The share of sugar plants and products has stayed around 2% (starch was found in other products) and the share of other plant products climbed from 2% to 3% (Figure 5.3). These evolutions impact nutritional security.

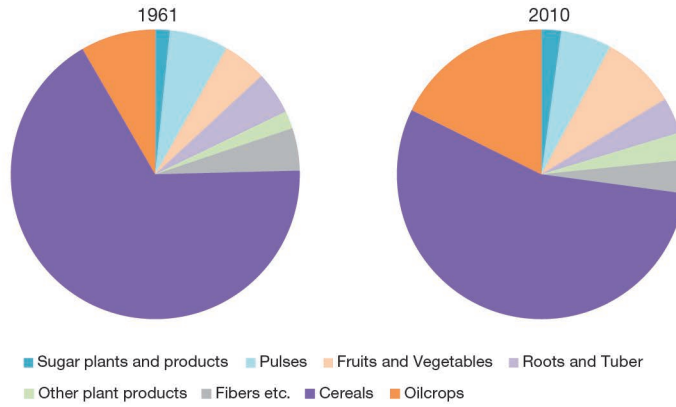
Areas devoted to permanent meadows and pastures increased from the 1960s to the mid-1990s and then slowly decreased. Over the whole period, the world area of permanent

Figure 5.2. World agricultural area evolution from 1961 to 2010 (1,000 hectares).



Source: FAOStat.

Figure 5.3. Shares of the world harvested areas of 8 crops in 1961 and 2010 (%).

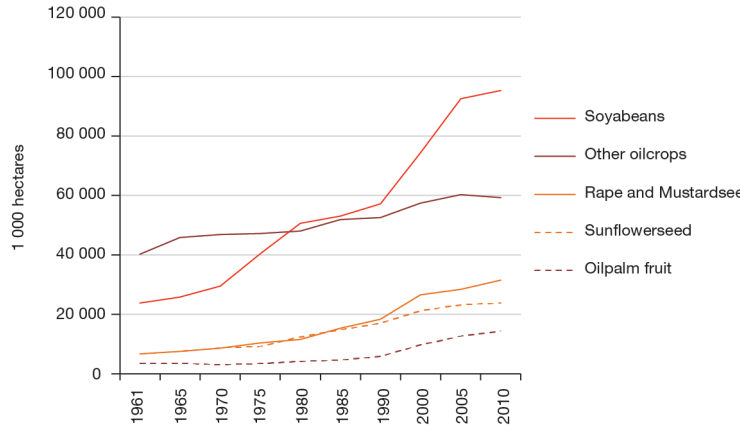


Source: FAOStat.

Figure 5.4. Evolution of world harvested areas of cereals from 1961 to 2010 (1,000 hectares).

Source: FAOStat.

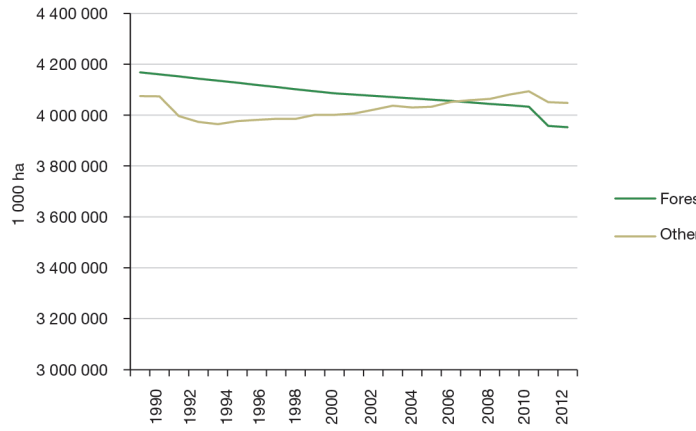
Figure 5.5. Evolution of world harvested areas of oil crops from 1961 to 2010 (1,000 hectares).



Source: FAOStat.

meadows and pastures rose from 3,078 million hectares in 1961 to 3,358 million hectares in 2010, *i.e.* about +7.3 million ha per year (Figure 5.2). There are, however, regional differences. In China, Brazil, MENA (Middle East and North Africa), and FSU, permanent

Figure 5.6. Evolution of world area under forests and other uses from 1990 to 2010 (1,000 ha).



Source: FAOStat.

meadows and pasture areas have increased significantly throughout the period. In contrast, pasture areas have decreased in Asia, especially India (–26%) and in OECD (–17%) (Manceron *et al.,* 2014). Pasture areas have remained more constant in Latin America (excluding Brazil) and sub-Saharan Africa. At the world level, forests areas have decreased (from 4,168 million hectares in 1990 to 4,033 million hectares in 2010, *i.e.*, –3.3%) (Figure 5.6).[25]

The use of land for livestock has grown over the period, and livestock mobilizes large areas of pasture and cropland with pastures covering about 2.2 times more land than arable crops (Manceron *et al.,* 2014). However, competition between feed and food has to be framed in term of protein conversion efficiencies and 'land opportunity'. Also, grasslands have a critical role in the valorization of non-arable land for producing food; almost 60% of all permanent pastures are efficiently used for producing food with no direct competition with cropland for food production (Manceron *et al.,* 2014). However, three trends can be observed: there are regions (*i.e.*, China, Brazil, Middle East, North Africa and FSU) where permanent pastures areas increased significantly between 1961 and 2010 but to a much smaller extent than ruminant production. In contrast, pasture areas decreased in other regions (*i.e.*, India: –26%, Oceania: –16%, Canada/USA: –6%, Asia excluding India and China: –14% and UE27: –13%). Finally, pasture areas remained rather constant in Latin America (excl. Brazil/Argentina) and sub-Saharan Africa (FAOStat, see also Chapter 12).

25. In FAOStat, data on areas under forests are not available before 1990.

Regional overview

The Second World War has had a profound effect on the spatial distribution of land (FAO, 2000). Agriculture suffered massive devastation during the war throughout Europe, in the USSR, in large areas of Asia and the Pacific, and in North Africa. In sharp contrast, food supplies were abundant in producer countries that had been relatively spared by the conflict – Canada, the United States, Australia and Argentina – and these countries took on the role of food suppliers for their allies and made a special effort to stimulate their output. After the war, Asia was considered to have problems of an almost insurmountable nature because it had half of the world's population but only one-fifth of the earth's land; the political situation was extremely unstable. Africa's situation then looked better as the war years had led to a strong demand for agricultural commodities, especially many industrial crops, and minerals, whose production had developed. We will now look at what happened in each region since 1960.

Agricultural areas have decreased in OECD countries between 1961 and 2010. The decrease has been much sharper in the EU27 (from 141 to 119 million hectares for arable and permanent crops areas, *i.e.* –15.6%, and from 78 to 68 million hectares for permanent meadows and pastures, *i.e.* –12.8%) than in Canada and USA (from 231 to 207 million hectares, *i.e.* –10.4%, and from 282 to 264 million hectares, –6.4% respectively).

Since the 1970-1990 period, there has been a territorial specialization in the distribution of land in Europe. On the one hand, there are highly productive intensive farming and forestry areas and, on the other, increasingly marginalized small-scale farm mosaics and extensive land use systems, or even abandoned land. Hotspots for the decline of cropland are found mainly in Eastern Europe and the Mediterranean. Cropland expansion has been rare overall, and occurred mainly in the Netherlands, Northern Germany, some areas in central France and Ireland. Large areas of Europe have been characterized by stable cropland patterns (Kuemmerle *et al.,* 2016). Wheat, maize, oats, barley, oilseed rape and soyabean have progressively become the crops covering the majority of cultivated areas. Bovine and especially dairy production have grown rapidly but without increasing pasture areas thanks to yield improvements, animal feed imports, geographic concentration and increasing specialization of rations, species, and systems. The contribution of these systems to water contamination is increasingly questioned.

In the FSU, since 1991, the arable land and permanent crops area has decreased by –14.6% and reached 195 million hectares in 2010. This has mostly taken place in Russia, Ukraine and Belarus. In this land abandonment, socio-economic factors have probably played a greater role than physical factors (Alcantara *et al.,* 2013). The decrease in arable and permanent crops areas has been compensated by an increase in permanent meadows and pastures: between 1991 and 2010 meadows and pastures have experienced a +11% expansion, reaching 362 million hectares in 2010. Within the arable and permanent crops harvested area, the share of sunflower grew considerably (from less than 3% in the 1990s to more than 9% in 2010), while the share of cereals (mainly wheat, corn, and barley) decreased (from 77% in the 1990s to less than 74% in 2010). Nevertheless, cereals remain

the main production, with wheat representing 2/3 of cereal areas. Large areas are also devoted to sugar plants (13% of harvested area in 2010). Urban agriculture covers small areas but is practiced by half of the urban population (Boukharaeva and Marloie, 2011).

In North Africa and the Near and Middle East, there has been an +11% increase in arable and permanent crops areas over the 1960-2010 period because of the expansion of permanent crops areas (+117%) reflecting the growth of fruit trees production for exports. Other major productions are cereals (mainly wheat) and sugar plants. Permanent meadows and pastures areas increased until the early 2000s and has decreased since then. Livestock production has grown four-fold, driven by intensification in dairy and poultry breeding; cereals and cakes are imported. In the MENA region, since 1990, 100% of the land considered as suitable for agriculture is exploited.

Arable land increased only slightly in Asia, between 1961 and 2010 (from about 340 to 369 million hectares) but permanent crop areas more than tripled (from about 22 to 74 million hectares). Permanent meadows and pastures climbed from 276 to 541 million hectares. The regional expansion of agricultural land and practices such as shifting cultivation has caused deforestation (UNEP-asia, 2016). While the largest areas of arable land are still devoted to rice and sugar plants, there has been a major increase in the area devoted to fruit and vegetables, soyabean, fibres, oil palm, and maize. Areas devoted to other cereals and pulses have decreased. The expansion of permanent pasture is due to the growing consumption of animal products in the region (a 10-fold increase over the period).

In Latin America, between 1961 and 2010, the land area devoted to arable and permanent crops has risen from about 100 million hectares to 184 million hectares (+84%); the area of meadows and pastures went up from 460 million hectares to 559 million hectares (+22%) and seems to stabilize by the end of the period. LAC, especially Brazil and Argentina, has become a major producer of soyabean, overtaking North America, but also of sugar plants in addition to fruit and vegetables; the share of soyabean in total harvested area has gone from 0.5% in 1961 to nearly 40% in 2010. LAC has remained a major producer of maize and wheat. Starting in the 1980s, Brazil and Argentina took advantage of the huge increase in demand from China and deforested to plant soyabean. Since the 2000s, soyabean is essentially planted on acid soils previously considered unsuitable for agriculture. Between 1961 and 2010, the area under forests went down by –9%.

In SSA, between 1961 and 2010, arable land and permanent crops increased from about 144 to 230 million hectares (*i.e.* +60%), permanent meadows and pastures went from 801 million to 827 million hectares (*i.e.* +3%); forests areas decreased from 741 million hectares in 1990 to 666 million hectares in 2010 (*i.e.* –10%). SSA differs from the other regions: most food commodities are for domestic consumption and interactions between crops and livestock are strong. In this region, in 2010 about 22% of the land listed as agricultural is actually cultivated for crops, and the majority is grazing land used for breeding livestock. In 1960, 15% of the land listed as agricultural was cultivated for crops. Plant-based food production has increased by +2.6% per year on average since 1970, a rate similar to the one seen in Asia (+2.7%) and slightly higher than the global average

(+2.15%). The largest areas of arable land are devoted to 'other cereals' (millet, sorghum etc.), maize, roots and tubers, pulses, and fruit and vegetables, which is linked to domestic diets. Areas devoted to 'other cereals' have increased by about +87% between 1961 and 2010. Areas devoted to oil palm have decreased but current restrictions on logging and the acquisition of land in Asia are pushing investors back to West Africa and the Congo Basin.

Degree of intensity of land use

THE DEGREE OF INTENSITY OF LAND use concerns farming practices, which depend on the techniques available and farmers' decisions. It is affected by technical progress, farmers' decisions and policies. Over the past 40 years, the intensity of land use has increased considerably at global level. According to the FAO (2011), in 1961, 0.45 hectare was necessary to feed one person. In 2010, about 0.23 hectare is cultivated per head of the world's population. High-income countries cultivate more than twice the area per capita (0.37 hectare) than low-income (0.17 hectare) countries, while middle-income countries cultivate 0.23 hectare per capita (FAO, 2011b). Europe today has some of the most intensively managed croplands in the world (Kuemmerle *et al.*, 2016).

We present here a retrospective overview of cropping intensity ratios and observed yields per hectare, the two quantitative indicators used by Agrimonde-Terra in the foresight process as far as land use intensify is concerned. In order to improve the intensity of land use, since the 1960s the transfer of technology model has dominated the organization of agricultural knowledge processes in developing countries and meant disseminating improved seeds, training farmers in chemical input use and simplified practices, and developing irrigation and mechanization (McIntyre *et al.*, 2009). We will present a very brief retrospective of yields of major cereals crops and cropping intensity ratios. Then we will also present a retrospective of the use of improved and genetically modified crops, of fertilizers and pesticides, of irrigation and of mechanization, which have contributed to improving the intensity of land use in the different regions of the world.

Cropping intensity ratios

According to Ray and Foley (2013, p.2): "the growth in annually harvested cropland and standing cropland has been changing in recent decades… While standing cropland area increased at the rate of about 3.5 million ha/year (from about 1.37 billion ha in 1961 to about 1.55 billion ha in 2011), the annually harvested land increased at a much faster rate of about 5.5 million ha/year (to reach about 1.38 billion ha in 2011 from about 1.06 billion ha in 1961). The ratio of annually harvested land to total standing cropland has been increasing over time as well (from 0.78 to 0.89 between 1961 and 2011), showing that the world's cropland harvesting frequency has been increasing significantly. In fact, the frequency of land harvesting increased even faster between 2000 and 2011; globally, annually harvested land increased at the rate of about 12.1 million ha/year which was approximately 4 times faster than the rate for standing cropland expansion (about 2.9 million ha/year)."

Ray and Foley (2013) point out regional differences in the cropland harvest frequency: in most of Western Europe, land is used consistently; however, a few countries (*e.g.*, Austria, France, Germany, Portugal and Italy) are increasing cropland harvest frequency. A number of Eastern European countries are decreasing their cropland harvest frequency with the exception of Poland and Ukraine. In America, many countries are increasing their cropland harvest frequency with the exception of Argentina, Mexico, Cuba and the Dominican Republic, where it is decreasing. Most Asian countries have increased their cropland harvest frequency. In the past decade, China has gone from 1.24 to 1.40 harvest per year and India from 1.08 to 1.21 harvest per year. Given the quality of soils, this growth will probably not last in the future. In many sub-Saharan African countries, the trend is towards negative cropland harvest frequency change, either because of an increase in crop failures or fallow periods, or an increase in cropland areas that have not been brought into production, or of a reduction in double- and triple-cropping, or the fact that more than 95% of agriculture area is rainfed.

Yields of major cereal crops

Average cereal yields over the last 50 years varied from about 373 kg per hectare in Namibia to 6,215 kg per hectare in the Netherlands, and there were 38 countries that had average yields over 3,000 kg per hectare (Liu *et al.*, 2015). The average cereal yield increased from 1,258 kg per hectare in 1961 to 2,925 kg per hectare in 2010 (Liu *et al.*, 2015). A retrospective evolution of maize, rice and wheat yields is provided by Ray *et al.* (2012), Iizumi *et al.* (2014) and Grassini *et al.* (2013), and despite different datasets and methods, they show quite consistent results and highlight different aspects. After a period of significant yield improvements, three yield trajectories are identified: continued growth, stagnation and decline. Globally, rice and wheat yields have reached upper plateaus (33% and 27% of cases reported by Grassini *et al.,* 2013) or are stagnating (23% and 24% of Grassini *et al.*'s 2013 cases, and in 35% and 37% of harvested areas according to Ray *et al.,* 2012). Maize (26%) has fewer cases of yields reaching an upper plateau (5% of cases according to Grassini *et al.,* 2013) and stagnation (33% of cases according to Grassini *et al.*, 2013, and 26% of harvested areas according to Ray *et al.*, 2012). Ray *et al.* (2012) also report yield stagnation for 23% of areas with soyabean. Collapses of yields are identified in 3% of maize areas, 1% of rice areas and 1% of wheat areas (Ray *et al.,* 2012).

In Europe, there is evidence of wheat yield stagnation and, in some areas, of maize. In the United States, especially in the western part, wheat yields are stagnating. In Asia, there is evidence of maize, rice, wheat and soyabean stagnation; rice yields are stagnating in China, India, and Indonesia across 79%, 36% and 81% of rice-growing areas respectively (Ray *et al.,* 2012). This raises major concerns for the future of production under current conditions. In Africa, there are major intra-regional differences for maize as well as for rice in West Africa. In Botswana, Kenya, Madagascar, Zambia, and Zimbabwe, maize yields are collapsing (Iizumi *et al.,* 2014). In Latin America, maize yields are still improving nearly everywhere except in Mexico, and soyabean yields are stagnating in some parts of Brazil (Ray *et al.,* 2012).

Based on literature reviews, Grassini *et al.* (2013) make hypotheses about the factors contributing to yield plateaus and stagnation. These are the fact that the crop reaches

its biophysical yield ceiling in the region where it is produced, but also "cyclical weather patterns, land degradation, shift in the location of production area to regions with poorer soils and climate, policies on the use of fertilizers and pesticides, and insufficient or poorly oriented investment in agricultural research and development," (Grassini *et al.,* 2013, p.5).

Improved and genetically modified crops

Breeding programmes developed early in the 20th century in the USA and European countries. There had been major technological advances in the 1950s. In the 1990s, molecular breeding accelerated the pace of progress and the precision of plant genetics and breeding. Since the 2000s, the introduction of a multitude of 'omics' tools provided an unprecedented ability to dissect the molecular and genetic basis of traits as well as the characterization of whole genomes (Kumpatla *et al.,* 2012).

Since 1960, the crop varieties planted by farmers in cultivated systems have shifted from locally adapted and developed populations to more widely adapted varieties produced through formal breeding systems (modern varieties). Roughly 80% of the wheat area in developing countries and three-quarters of the rice area in Asia is planted with modern varieties (MEA, 2005b). For other crops, such as maize, sorghum and millet, the proportion of area planted with modern varieties is far smaller (MEA, 2005b). International research programmes for the improvement of maize, wheat and beans, with funding from the Rockefeller and the Ford Foundations, played a major role in the creation and diffusion of improved varieties in Latin America, Asia and Africa (McIntyre *et al.*, 2009). Private companies also invested very early in plant breeding and since the 1990s, seed, agrochemical, and pharmaceutical companies have merged into 'life science' companies. Commercial transgenic crops were introduced in 1996; they covered about 4% of the global cropland area in 2004 and 12% in 2016 (185 million hectares) (ISAAA, 2016). The crops mostly concerned are maize, soyabean, cotton and beets. In 2016, genetically modified crops were found in 26 countries, 19 developing and seven industrial countries; the USA grew 39% of the global total, Brazil 27%, Argentina 13%, Canada 6%, and India 6% (ISAAA, 2016).

This has been facilitated by evolutions in the international and legal contexts. The International Convention for the Protection of New Varieties of Plants (UPOV) was signed in 1961 providing a *sui generis* protection to crop varieties with important exemptions for farmers and breeders (McIntyre *et al.*, 2009). In the 1970s, the European Patent Convention stated that plants and animals are not patentable, but in the 1980s, the first patents were granted to living organisms by US courts, and the European Patent Office moved to grant patents on plants in 1999 (McIntyre *et al.*, 2009). In the 1990s, the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) spurred a debate on plants and varieties in developing countries. The UPOV Act prohibited farmers from sharing seed of protected varieties. Throughout the period, the FAO was involved in discussions, notably with the Commission on Plant Genetic Resources for Food and Agriculture (CPGRFA) and the FAO-International Undertaking (IU-PGRFA), but did not really manage to protect local varieties and small farmers (McIntyre *et al.*, 2009).

Fertilizers and pesticides

The application of chemical fertilizers and pesticides in agricultural systems has been considered to be an important means to improving crop yields. Over the past two decades, efficiency of use, and impacts on yields and the environment have however been widely debated, and inefficiency and negative impacts are increasingly noted (Liu *et al.,* 2015; Mueller *et al.,* 2017).

The fertilizer industry is linked to the countries which control the production of the primary materials needed to produce fertilizers, *i.e.* Canada, China, the United States, India and Russia (IPES-Food, 2017).

Globally, there is unequal availability of fertilizers, and therefore application rates. Consumption per hectare of harvested area and nitrogen use efficiency vary a lot per country and within countries (Nesheim *et al.,* 2014; Liu *et al.,* 2015; Mueller *et al.,* 2017). In Asia, the consumption of fertilizers was promoted during the Green Revolution (Pingali, 2012) and its use is widely spread. East Asia accounts for 41% of global nitrogen consumption, 37% of global phosphate consumption and 31% of global potash consumption, and South Asia accounts for 19%, 22% and 17% of global consumption of the three fertilizer types respectively (UNEP, 2013); Malaysia consumed more than 800 kg of fertilizers per hectare of harvested area in 2010 (Liu *et al.*, 2010). In contrast, most African countries use few fertilizers: 80% of African countries lack nitrogen and in 2010, eleven countries were using less than 50 kg of fertilizer per hectare (Liu *et al.,* 2015). In Latin America, phosphorus scarcity is widespread. However, at global level, the observed nitrogen use efficiency (NUE) has "declined from an average of 54% N recovery in harvested materials during 1961–1977 to 47% N recovery during 1994–2009." (Mueller *et al.,* 2017, p.7).

As far as pesticides (insecticides, herbicides, fungicides and bactericides) are concerned, the USA consumed the largest amount of insecticides followed by India. Twenty countries consumed more than 2 kg per hectare of insecticides in 2010, with 12 nations in North and South America; whereas countries located at high latitudes used less than 45 g per hectare (Liu *et al.,* 2015). In Africa, most countries officially import few pesticides, but smuggling of pesticides is largely practiced (Chapter 15). Most pesticides are provided by agricultural input industries which have become highly concentrated during the period 1994-2009 (Fuglie *et al.,* 2011). In 2014, the world's six largest agrochemical corporations controlled 75% of the global pesticides market and also 60% of the global seed market (IPES-Food, 2017).

Irrigation

Agriculture is by far the biggest economic sector to use water. Irrigated systems have an impact on land intensity as it can boost agricultural production. Between 1961 and 2010, while the arable and permanent crop area increased by +12%, land under irrigation more than doubled and continues to grow; 40% of irrigated areas are reliant on groundwater either as a primary source or in conjunction with surface water (FAO, 2011b). In 2012, more than 324 million hectares were equipped for irrigation worldwide, *i.e.* 21% of the

area devoted to arable land and permanent crops. However, 71% of the irrigated areas (about 230 million hectares) are in Asia, and 25% are in the Americas and Europe. In Asia, in 1961, 19.6% of area devoted to arable and permanent crops was irrigated and this percentage climbed to 41% in 2012. Asia's irrigated areas are mostly in China and India. In South America, the percentage rose from 6.5% to 10.5% between 1961 and 2012. In North Africa, it went from 17.1% to 25.6%, whereas in sub-Saharan Africa, it went from 2.4% to 3.4%. Inefficient use of water for crop production depletes aquifers, reduces river flows, degrades wildlife habitats and leads to salinization of irrigated land (FAO, 2016a).

Mechanization

At the production level, agricultural mechanization (*e.g.*, for crop establishment, weeding, fertilization, irrigation, crop protection and harvesting) leads to substitution of labour by capital. There are different levels of mechanization and sizes of machines (Böttinger *et al.*, 2013), and the machines can contribute in various manner to increasing the intensity of land use. According to Böttinger *et al.* (2013), in the European Union, there are a high number of machines per hectare reflecting over-mechanization and a tendency to fewer and higher-powered machines; in the USA, farms are completely mechanized and there is a trend towards larger and higher-horsepower equipment and automation; in Japan, agriculture is highly mechanized but mostly with small, sophisticated and specialized machines, with a trend towards more automation; in FSU, machines and tractors are old and their replacement is slow. In Latin America, Asia and the Near East, there has been an increase in engine power leading to a fall in the number of draught animals, although at local level animals can still be very important. For example, in Latin America and the Caribbean, tractor numbers increased 1.7 times between 1961 and 1970, and thereafter tripled to reach 1.8 million in 2000 (FAO, 2016a); in Asia, the number of tractors increased five-fold between 1961 and 1970, and then ten-fold, reaching 6 million units in 2000 (Sims *et al.*, 2016).

In sub-Saharan Africa, in 1961, the number of tractors in use (172,000) exceeded the number both in Asia and the Near East, but have since increased slowly, peaking at 275,000 in 1990, before falling to 221,000 in 2000 (Sims *et al.*, 2016); draught animal power and human muscle power still play a major role.

Services provided by land: employment, regulating, supporting and cultural services

Land use provides employment, and benefits from and influences ecosystem services, such as the provision of services (the material benefits people obtain from ecosystems such as water, food, wood and other goods), regulating services (maintaining air and soil quality, providing flood and disease control, or pollinating crops), supporting services (providing living spaces for plants or animals and maintaining a diversity of plants and animals), and cultural services (the non-material benefits people obtain from ecosystems).

Lack of data and indicators make assessments difficult and subjective. Nevertheless, from 2001 to 2005, the Millennium Ecosystem Assessment addressed the consequences of ecosystem change for human well-being. We present here a very brief overview of the situation of agricultural employment, and provide some information on regulating services and supporting services in the different regions of the world.

Agricultural employment

Agricultural land use provides direct employment through agricultural production, forestry, hunting etc. and indirect employment through food, wood and biomass value chains. At global level, there is a decline in direct agricultural employment: in 1991, direct agricultural employment represented 43.4% of the global work force; in 2010, it represented 30.8%, and in 2017, the estimation is 28.4%, which means that about 946 million people around the globe are employed in world agriculture, representing slightly less than 1 in 3 of all workers. Between 1991 and 2010, the decrease in agricultural employment has been particularly sharp in East, South-East and South Asia, Northern, Southern and Western Europe, Northern America and the Middle East (Table 5.1). In 2010, there are regional contrasts in employment in agriculture as a percentage of total employment: the percentage is very low in OECD countries (around 3.6%) and very high in SSA (around 62%); it remains high in South Asia (39%) and East Asia (30%) (Table 5.1). In the latter regions, the proportion

Table 5.1. Employment in agriculture, by region, as share of total employment (1991 and 2010).

Region	% in 1991	% in 2010
World	43.4	30.8
Northern, Southern and Western Europe	7.7	4
Eastern Europe	15.5	11.7
Northern America	3	1.7
East Asia	49.5	24.4
South-East Asia & Pacific	57.1	39.3
South Asia	62	49.7
Latin America & Caribbean	25	16.9
Middle East	24.5	14.3
North Africa	35.2	30.4
Sub-Saharan Africa	67.5	58.7

Source: International Labour Office (ILO). Employment by sector - ILO modelled estimates, November 2017.

of poor people in the agricultural sector is very high and the role of women, children and forced labour is largely unrecognized. Also, many agricultural workers are excluded from national labour laws, have low wages and dangerous working conditions (ILO, 2007).

Regulating, supporting and cultural services

The Millennium Ecosystem Assessment (2005) reports that: "Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fibre, and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth. The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of the degradation of many ecosystem services, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people. These problems, unless addressed, will substantially diminish the benefits that future generations obtain from ecosystems" (MEA, 2005b, p.1). In 2005, approximately 60% (15 out of 24) of the ecosystem services examined during the Millennium Ecosystem Assessment were degraded or used unsustainably, and therefore there was a degradation of regulating, supporting and cultural services. The harmful effects of the degradation of ecosystems are the emission of greenhouse gases, a significant rise in the number of floods and wildfire, land, water and air degradation and pollution, a decline in genetic diversity among cultivated species, a decline in the occurrence and diversity of wild pollinators[26] and an increase in the incidence of infectious diseases and zoonotic pathogens etc. (MEA, 2005b). They are especially being borne by the poorest, contributing to growing inequities. A few years later, Rockström *et al.* (2009) proposed the concept of "planetary boundaries" to describe "thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems" (Rockström *et al.,* 2009, p.1). Steffen *et al.* (2015) estimate that changes at the level of sub-systems will impact the functioning of the Earth's system as a whole.

Biodiversity decline and loss has been very high in Eastern and Western Europe, but with lower rates in Central Europe, Russia and Central Asian countries. The Caucasian Mountains, the Carpathians, the mountains of Central Asia and the Irano-Anatolian highlands still have high species richness and harbour many endemic species (UNEP/UNECE, 2016). Wild pollinators, in North West Europe and North America, have declined in occurrence and diversity (and abundance for certain species) at both local and regional scales (IPBES, 2016). Human habitat, infrastructure, agriculture, industry and mining as well as poor waste management put heavy pressures on land and are badly affecting soil and water quality, and leading to the removal of open and green spaces and impairing

26. The volume of production of pollinator-dependent crops has increased by 300% over the past five decades, and overall these crops have experienced lower growth and lower yield stability than pollinator-independent crops (IPBES, 2016). They are affected by intensive agricultural practices.

cultural services. Pesticide use and stockpiles of hazardous chemicals are a major concern for public health and ecosystem integrity (WHO, 2010).

In Africa, biodiversity is considered to still be very high both in terms of species and ecosystem types and, with certain notable exceptions, in remarkably good condition. The Congo Basin rainforest is the second largest tropical rainforest in the world and Lake Victoria is the second largest freshwater lake in the world (UNEP-africa, 2016). Biodiversity is contributing to food supply, traditional medicines and tourism. However, it "faces significant threats from illegal trade in wildlife, mono-cropping, air and water pollution, forest loss, climate change, and increased prevalence of invasive alien species" (UNEP-africa, 2016, p.77). Lack of valuation of biodiversity contributes to inadequate conservation efforts. On average, the population has sufficient water to meet their needs, but assessments at the local level reveals disparities in access to water resources. The cultural value of ecosystems is rated highly by both traditional local and affluent urban communities (MEA, 2005b).

LAC benefits from an exceptional variety in its biodiversity (*e.g.*, in Brazil, Colombia, Ecuador, Mexico, Peru and Venezuela), and has been the centre for the domestication of plant species (cassava, common beans and maize, for example, in Central America and the Andes-Amazon). At the household and local levels, huge varieties of plants are cultivated for food, fibre and medicinal purposes. Land plays an important role in the culture of indigenous populations. Many countries are involved in initiatives to reduce emissions from deforestation and forest degradation (REDD), and to foster and recognize the environmental services of forests for the region and the world. They seek to achieve a valuation of environmental services provided by forests, as well as for carbon capture and biodiversity conservation. However, land-use change, including degradation and fragmentation of natural habitats, conversion of natural habitats to agriculture and pastureland, and expansion of certain crops such as sugar cane, soyabean and coffee plantations as well as places to rear livestock put the services provided by land at risk (UNEP-lac, 2016).

In Asia and the Pacific, biodiversity has been damaged by agriculture, overgrazing and conversion to forest plantations and natural forest logging (UNEP-asia, 2016). Of the 2 billion hectares of dryland in Asia, more than half are affected by desertification; the increasing dust storms are attributed to wind-related desertification processes, resulting from human impacts in arid, semi-arid and sub-humid regions of Northern China (UNEP-asia, 2016). Shifts in the composition of forests and water scarcity are also diminishing ecosystem services.

Conclusion

The retrospective overview of land use in the world underlines important challenges for the five dimensions of land use.

The agronomic potential of land is already over utilized in North Africa, the Near and Middle East, the South Mediterranean zone, China, Rwanda and Burundi. In India, the rest

of Asia, EU27 and West Africa, arable and permanent crops areas are getting close to the maximum cultivable area according to our retained assumption (*i.e.*, suitability index 1 to 4 from the GAEZ project). In these regions and/or countries which are highly populated, there is a scarcity of land for crops. All regions except Brazil/Argentina, Rest of America, North America, FSU and ECS Africa face constraints on the availability of land with good agronomic potential. As in the past, land's suitability for cultivation has been affected by inappropriate land-management practices, natural factors and climate change. The challenge of maintaining the agronomic potential of land in these areas and in the rest of the world is very important for global and local food security

Access to land has a legal dimension, but it also has social, demographic, political, economic, cultural and biophysical dimensions. Despite land reforms, access to land remains insecure in many countries. In recent decades, growing food demand, increased population density and conflicts have contributed to insecure access to land for millions of people, especially younger people and women, who wish to cultivate land, cannot access land or have access only to areas with a low agronomic potential, or their rights are contested, or they are kicked off their land, or are far away from markets, or their land is contested by other groups etc. Providing secure access to land is of crucial importance for the food security of millions of households.

As far as the distribution of land is concerned, the main challenge seems to be to control the expansion of areas for oil products (for food, feed and energy) and animal feed, and to ensure that land distribution provides healthy diets to the population. Pasture represents 2.2 times more land than arable land and a major challenge is to increase its capacity to store carbon in soils with appropriate management techniques.

Technology-driven intensification has improved the intensity of land use, especially yields, but the most common pattern has been the simultaneous increase in agricultural yields and cultivated areas (Rudel *et al.,* 2009). The relationship between yields and land saving is complex (Stevenson *et al.*, 2013), and technological change is only one parameter in land savings, and profitability for farmers plays a major role in land expansion at a local level (Angelsen and Kaimowitz, 2001). Over the past decade, yield plateaus and even falling yields have been identified in many crops and in many areas, despite the continuous progress in crop genetics and technologies. The negative impacts of the use of inorganic fertilizers and pesticides on human health and the environment are increasingly noted.

Finally, as far as the regulating and supporting services provided by land are concerned, there have been major breaks in the past 50 years. One challenge is the maintenance and development of pollinators and biodiversity, as these have a major impact on food production. Providing agricultural employment in Africa is another important challenge as the proportion of people employed in agriculture remains very high and other economic sectors are not developing.