Chapter 1. Overview

This chapter provides an overview of the latest set of quantitative medium-term projections for global and national agricultural markets. The projections cover consumption, production, stocks, trade, and prices for 25 agricultural products for the period 2019 to 2028. The weakening of demand growth is expected to persist over the coming decade. Population will be the main driver of consumption growth for most commodities, even though the rate of population growth is forecast to decline. Per capita consumption of many commodities is expected to be flat at a global level. Consequently, the slower growing demand for agricultural commodities is projected to be matched by efficiency gains in production which will keep real agricultural prices relatively flat. International trade will remain essential for food security in food-importing countries. World agricultural markets face a range of new uncertainties that add to the traditionally high risks facing agriculture. These include the spread of diseases such as African Swine Fever and the heightened uncertainty with respect to future trading agreements between several important players on world agricultural markets.

1.1. Introduction

The *Agricultural Outlook* presents a consistent baseline scenario for the evolution of agricultural and fish commodity markets at national, regional and global levels over the coming decade (2019-2028). The *Outlook* thus focuses on the medium term, complementing both short-term market monitoring and outlook publications and long-term projections.[1]

The projections in the *Outlook* are developed by OECD and FAO in collaboration with experts from member countries and international commodity bodies. The use of the OECD-FAO Aglink-Cosimo model links the sectors covered in the *Outlook* and ensures a global equilibrium across all markets. It further allows follow-up analysis, including a consideration of market uncertainties. A detailed discussion of the methodology underlying the projections as well as documentation of the Aglink-Cosimo model is available online.[2] Projections by commodity are discussed in detail in the online commodity chapters.

The projections in this *Outlook* are influenced both by current market conditions (reviewed in Figure 1.1) and by assumptions on the macro-economic, demographic and policy environment (presented in Box 1.4 at the end of this chapter). Over the *Outlook* period, world population is expected to reach 8.4 billion people, with most growth concentrated in Sub-Saharan Africa (+300 million people) and South Asia, notably India (+189 million people). Economic growth will be unevenly spread around the world, with strong per capita income growth in India and the People's Republic of China (hereafter "China") and weaker growth in Sub-Saharan Africa in particular. Despite robust per capita income growth among emerging markets, the level of income attained by 2028 is expected to remain significantly below levels in OECD countries. These and other assumptions are discussed in more detail in Box 1.4.

The projections are also subject to a number of uncertainties, discussed in detail at the end of the chapter and in each of the online commodity chapters.

Figure 1.1. Market conditions for key commodities

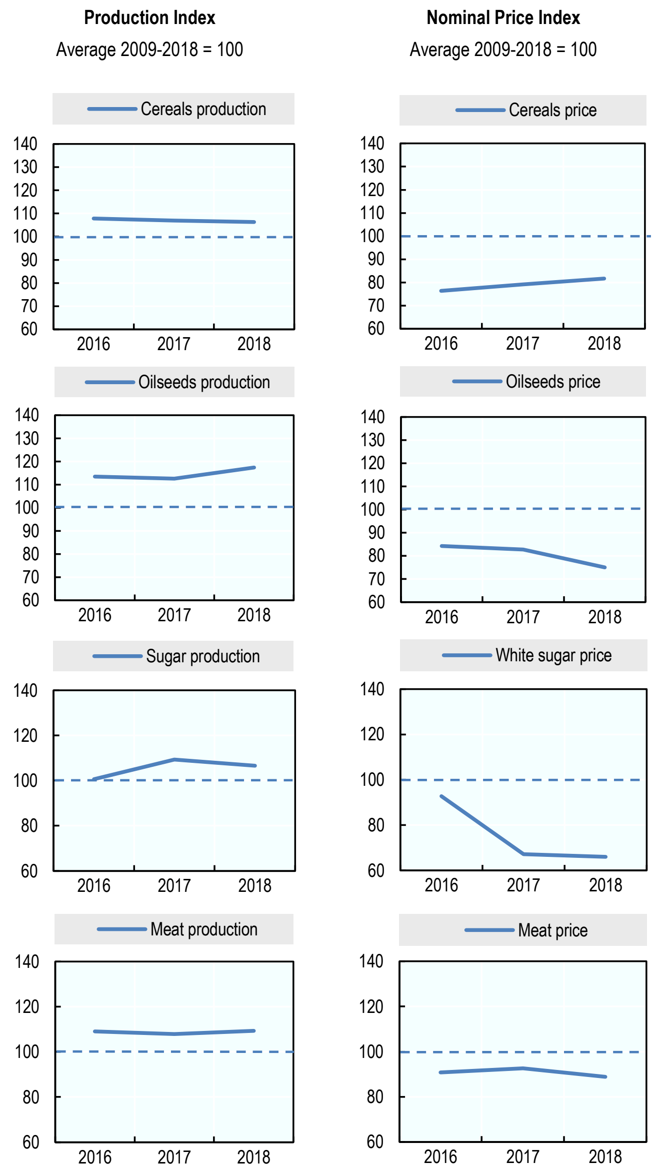
Current market conditions

Cereals: World production of cereals declined for the second consecutive year in 2018, driven by smaller wheat and other coarse grains harvests. In contrast, the maize crop was larger. Rice output was also higher in 2018, overtaking the previous year's record production. Global cereal stocks fell for the first time in six years.

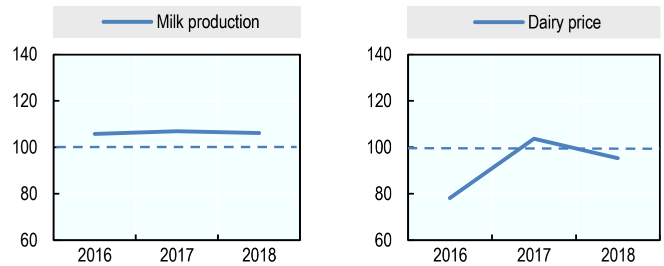
Oilseeds: The United States and Brazil recorded bumper crops for soybean in 2018. Demand for protein meals has tapered off given China's tariffs on US soybeans and moves to lower the share of protein meal in feed rations. Prices peaked in the first half of 2018, but have fallen since, in part due to high stocks and market uncertainties.

Sugar: Following a record production surplus in 2017-18, a smaller surplus is estimated for 2018-19 due to unfavourable weather conditions in India, Thailand and Europe. Growth in sugar intake remains strong in many developing countries. As a result of the continued production surplus, world sugar prices were relatively depressed for much of the 2017-18 season.

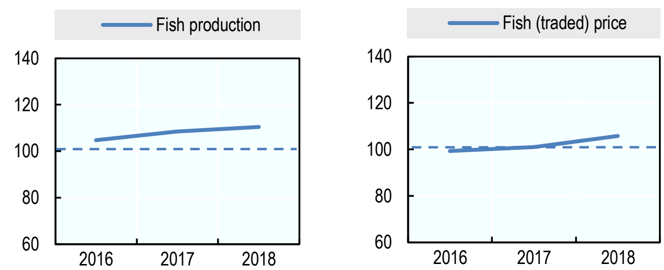
Meat: Production of bovine, pig and poultry meats increased in 2018, with much of the expansion originating in the EU, the Russian Federation and the United States. Output fell in the People's Republic of China (hereafter "China") due to the outbreak of African Swine Fever. Prices of pig and poultry meats declined while those of bovine meat remained stable.



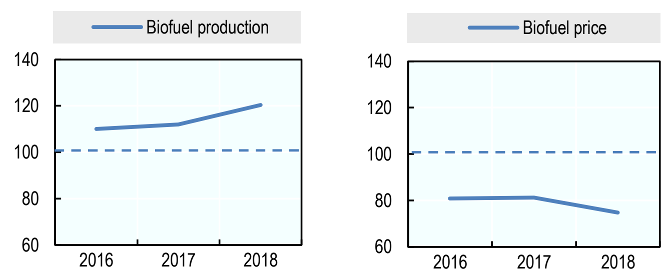
Dairy: World milk production experienced an increase by 1.6% in 2018, fuelled by a 3.0% increase in India and growing production in the three major dairy exporters (the European Union, New Zealand and the United States). Butter prices declined compared to the record levels of last year, while skim milk powder (SMP) prices recovered from low levels seen a year ago.



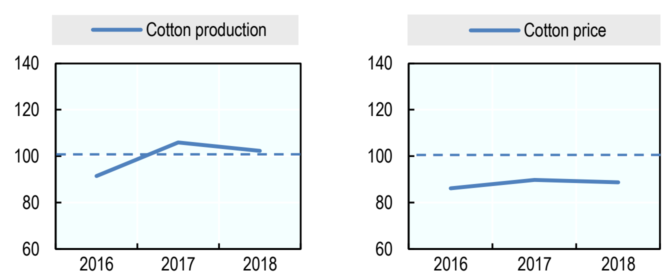
Fish: Production, trade and consumption all reached historical peaks in 2018. The growth in production was due to a slight increase in capture fisheries (mainly of anchoveta in South America) and the continued expansion of aquaculture production, at some 3-4% a year. Fish prices grew during the first part of 2018 and remain above 2017 levels for most species and products.



Biofuels: Global production increased in most major producing regions in 2018. Demand was sustained by obligatory blending and growing total fuel demand, although prices decreased due to ample supply. Decreasing price ratios of biofuels to conventional fuels resulted in additional non-mandated demand for biofuels, mainly in Brazil.



Cotton: Production fell by 3% in the 2018 marketing year as pest and weather problems plagued the major producers. Consumption grew strongly in Bangladesh, Turkey and Viet Nam. Global stocks declined to about 8 months of world consumption. Prices have been declining but continue to be high compared to polyester, the main substitute for cotton.



Note: All graphs expressed as an index where the average of the past decade (2009-2018) is set to 100. Production refers to global production volumes. Price indices are weighted by the average global production value of the past decade as measured at real international prices. More information on market conditions and evolutions by commodity can be found in the commodity snapshot tables in the Annex and the online commodity chapters.

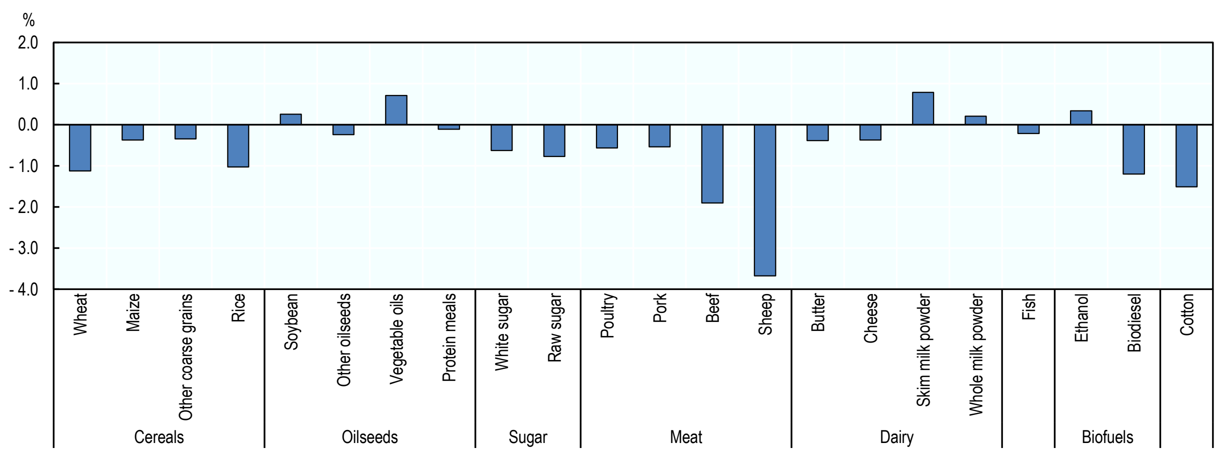
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957232

1.2. Prices

The *Outlook* uses prices at main markets (e.g. US Gulf ports, Bangkok) of each commodity as international reference prices. Near-term price projections are still influenced by the effects of recent market events (e.g. droughts, policy changes), whereas in the outer years of the projection period, they are driven by fundamental supply and demand conditions. Shocks such as droughts or recessions create variability around these price paths, which are explored through a partial stochastic analysis later in the chapter.

Figure 1.2. Average annual real price change for agricultural commodities, 2019-28



Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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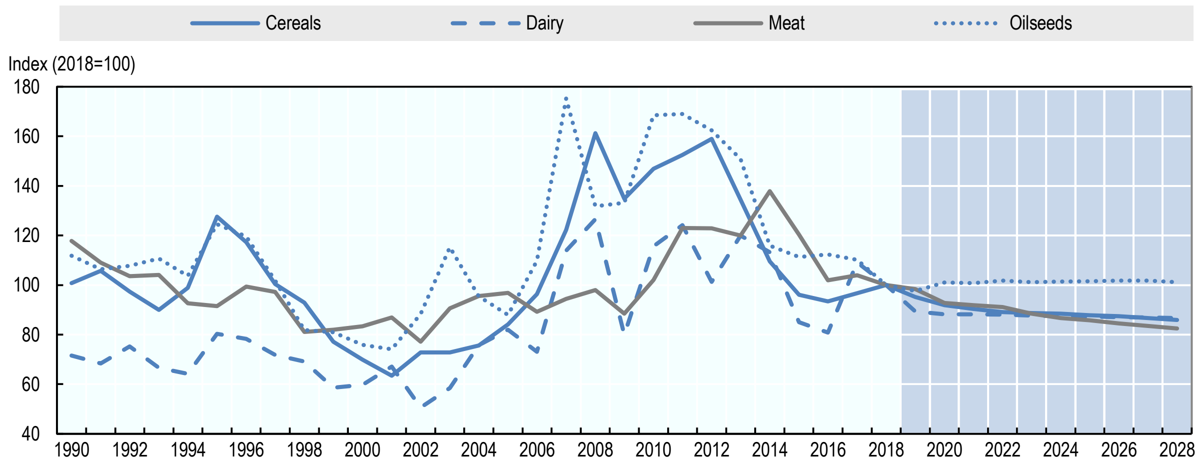
Most of the commodities covered in the *Outlook* are expected to see real price declines over the coming decade by around 1-2% per year (Figure 1.3), as productivity growth is expected to contribute to a gradual decline in real prices in the coming decade. Pronounced price declines are expected for beef and sheep. For beef, high prices in recent years have stimulated an expansion of the cattle inventory. Given the longer time needed to raise cattle, this will result in additional supply in the coming years, bringing prices back down. A similar process is at work for sheep prices, which increased by more than 20% in real terms between 2017 and 2018; this *Outlook* expects real prices for sheep meat to decline in the coming two years to their 2017 levels. For a few commodities (vegetable oil, skim and whole milk powder, ethanol) real prices are expected to be flat or increase slightly given their relatively low starting point.

Figure 1.3 puts these real price projections in the context of recent history. Prices for cereals, oilseeds, dairy and meat (among other agricultural commodities) saw strong increases between the early 2000s and 2007-14, with real prices in some cases doubling in a short period of time (Figure 1.4). Prices have fallen in recent years, however, and prices are projected to remain at or below current levels, as marginal production costs are assumed to decline further in real terms over the decade.

Figure 1.3. Medium-term evolution of commodity prices, in real terms



Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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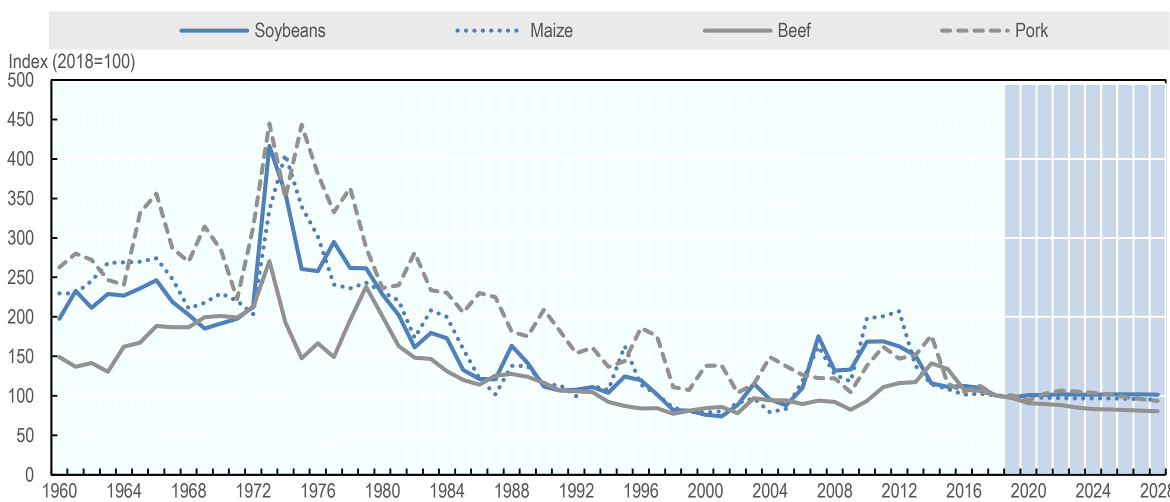
Figure 1.4. Long-term evolution of commodity prices, in real terms



Note: Historical data for soybeans, maize and beef from World Bank, "World Commodity Price Data" (1960-1989). Historical data for pork from USDA QuickStats (1960-1989).
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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The expected decline in real prices is consistent with a long-term downward trend (Figure 1.4). Historical data show that agricultural commodity prices tend to be highly correlated, and tend to follow a declining trend over the long run. However, the historical data also shows the possibility of periods of volatility and high prices interrupting the long-term trend. This was the case in the 1970s, as well as more recently. Price projections in this *Outlook* reflect structural trends over the coming decade, but unforeseen events (e.g. harvest failures, demand shocks) could create volatility around these trends.

Lower prices are a boon to millions of consumers worldwide, but also put pressure on the incomes of those producers who are not lowering their costs sufficiently through improved productivity. A low-price environment could thus lead to increasing demands for support to farmers, which could in turn affect the projections.

In addition to the evolution of international prices, domestic prices of agricultural commodities are influenced by several other factors such as transport costs, trade policy, taxation and exchange rates. Among these, changes in exchange rates are perhaps the main source of variation, as exchange rates can change significantly over a short period of time. While international prices provide information on global demand and supply conditions, commodities are typically quoted in US dollars, so that variations of exchange rates relative to the US dollar are an additional factor determining price evolutions. Assumptions on exchange rates are discussed in Box 1.4.

1.3. Consumption

The needs of a growing and more affluent global population for food and raw materials will drive the demand for agricultural commodities over the next ten years. Global utilisation is expected to be shaped in particular by the population-driven food demand in Sub Saharan Africa, income-driven demand for higher value and more processed foods in emerging economies and changing consumption patterns resulting from a steadily increasing health, environmental and sustainability awareness in advanced economies. Moreover, the economic growth assumptions are subject to an additional element of uncertainty, especially in view of the recent revisions pointing to an overall economic slowdown.

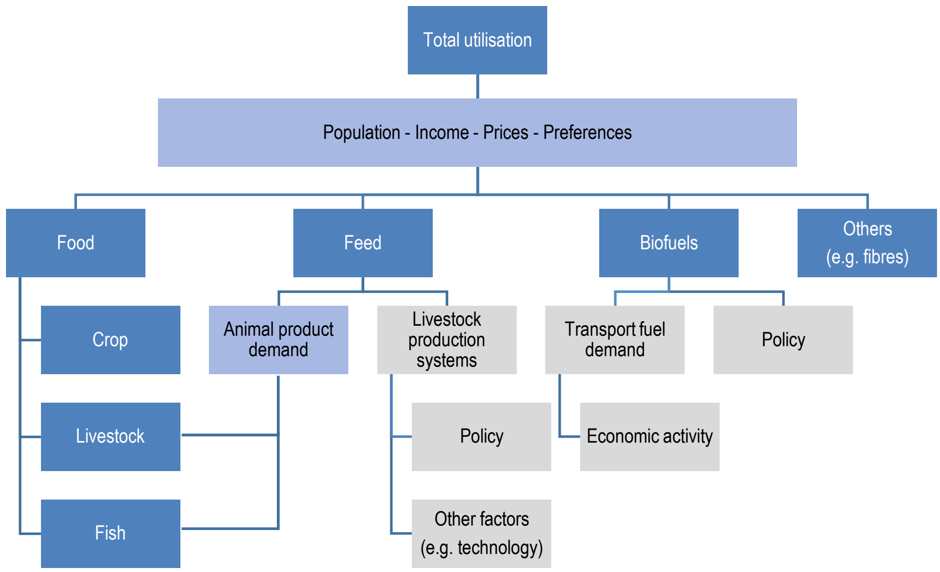
Drivers of agricultural commodity demand

Agricultural commodities are used as food, feed, fuel and raw materials for industrial applications. The demand is driven by a set of common factors, such as population dynamics, disposable income, prices and consumer preferences. Additionally, a number of specific drivers can be identified, as shown in Figure 1.5.

Population, income level, and preferences influence food demand directly, as they determine number of consumers, the desired food basket, and the ability to purchase these goods. Because of the considerable geographic differences in each of these factors, their relative influence on food use differs by country and region. In addition to these basic drivers, for non-food uses such as feed, fuel and other industrial applications, a number of specific factors can be identified. For example, feed demand is derived from a combination of the food demand for products of animal origin and the respective livestock production systems. They, in turn, depend on policies that set the context and on production technologies. Demand for agricultural products is also subject to broader policies that shape disposable incomes. Biofuels are a specific example of a policy driven demand. To project the actual use of biofuels and the derived demand for the various feedstocks several political and economic factors are assessed in the *Outlook* (for details see the biofuel chapter).

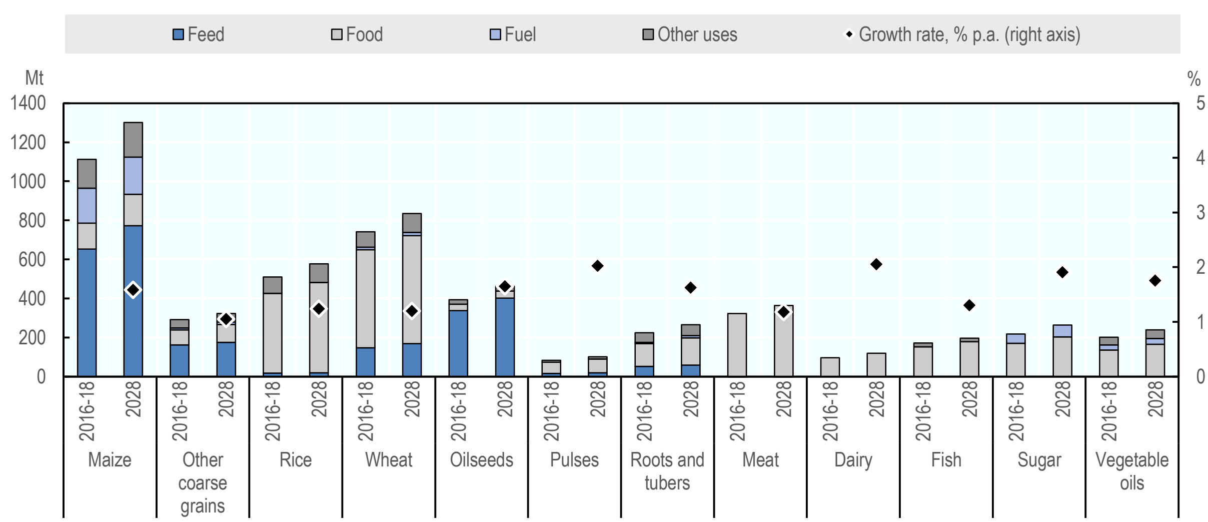
Food has been the primary use for most edible commodities, however feed and fuel uses have made significant gains in recent decades. In particular, the evolution of eating patterns towards a higher share of animal foods and the subsequent development of the livestock sector have increased the importance of feed. Growth in feed use of cereals is expected to exceed the expansion of food use over the coming decade, while biofuel feedstocks will maintain their strong position, without further gains (Figure 1.6).

Figure 1.5. Decomposition tree of main agricultural commodity uses and demand drivers



Note: Dark blue boxes represent the uses of agricultural commodities; light blue boxes represent the demand drivers; grey boxes represent production and policy factors.

Figure 1.6. Global use of major commodities



Note: Feed use of oilseeds refers to the oilseed equivalent of the protein meal component of crushed oilseeds; the oil obtained from crushing oilseeds is accounted for in "vegetable oils"; Dairy refers to all dairy products in milk solid equivalent units; Sugar biofuel use refers to sugarcane, converted into sugar equivalent units.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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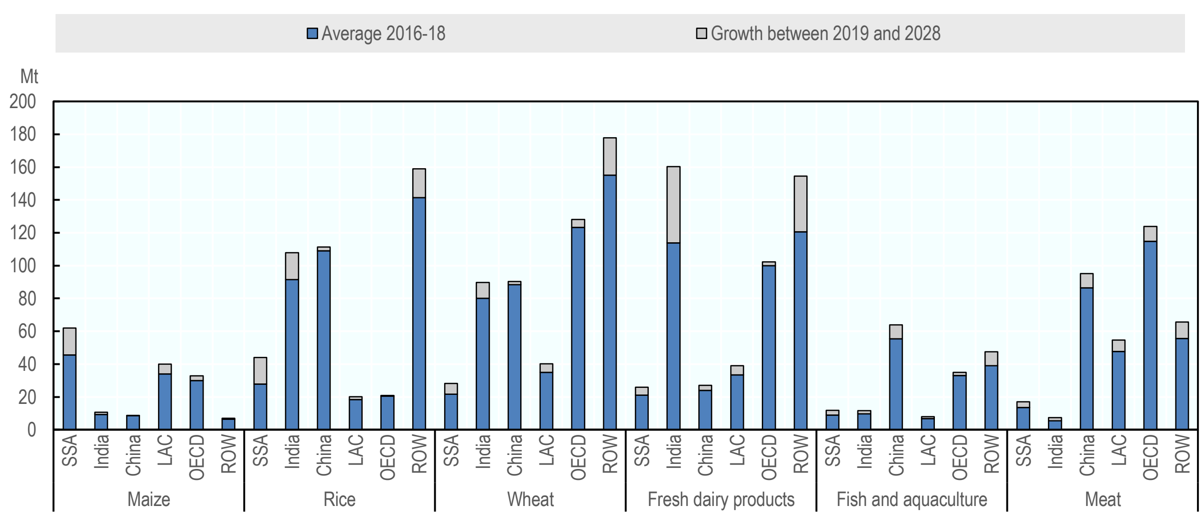
Global outlook for food use of agricultural commodities

Total food use of the commodities covered in this *Outlook* is expected to grow steadily over the next decade at rates of 1.2% p.a. for cereals, 1.7% for animal products, 1.8% for sugar and vegetable oils, and 1.9% p.a. for pulses and roots and tubers. In general, per-capita food consumption of staple products (cereals, roots & tubers, pulses) has levelled off globally and will be driven predominantly by population growth, while the evolution of higher value commodity (sugar, vegetable oils, meat, dairy products) demand will be based on a combination of per-capita use and population growth. As a result, demand for higher value products is projected to grow faster than for staples over the next decade.

Food use of cereals is projected to grow by 150 Mt over the outlook period, with rice and wheat accounting for the bulk of that expansion, each accounting for an additional 50 Mt by 2028. Consumption growth in animal products will come especially from continuously expanding consumption of dairy products, projected to expand by 20 Mt (milk solids equivalent) over the medium term. Meat consumption is expected to expand by 40 Mt and fish consumption by 25 Mt by 2028. The growth in sugar and vegetable oil consumption is estimated at about 30 Mt each. Regional differences in the level and growth rate of each commodity will persist, depending on the relative importance of the sub-sectors and drivers shown in Figure 1.7.

Figure 1.7. Regional contribution to food use of select commodities



Note: SSA is Sub-Saharan Africa; LAC is Latin America and Caribbean; ROW represents the rest of the world.
Source: OECD/FAO (2019), “OECD-FAO Agricultural Outlook”, OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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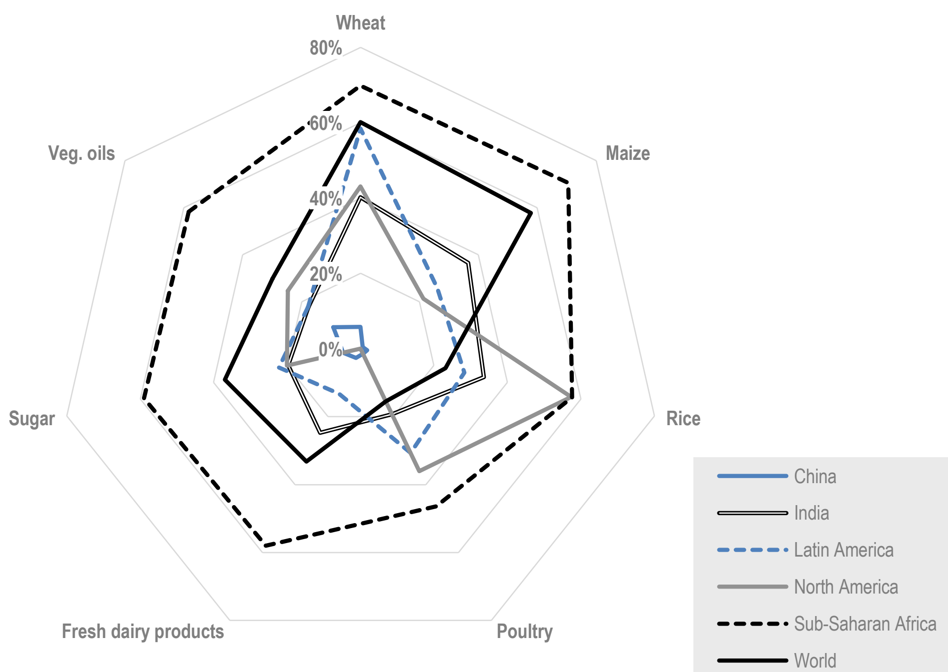
Population dynamics will shape the consumption of basic food commodities

Population represents the most significant factor behind the projected growth in food use of agricultural commodities, in particular for commodities that have high levels of per-capita consumption in regions with strong population growth. Global food use of cereals is expected increase by 147 Mt over the projection period, of which 42% (62 Mt) is projected come from Africa; about 90% of the expansion in African cereals consumption can be attributed to population growth.

The relative importance of the two main drivers of total demand for agricultural commodities, per-capita demand growth and population dynamics, varies widely across regions and commodities (Figure 1.8). For cereals, the importance of population as a driving factor tends to remain high across regions, as per-capita demand is stagnant or even decreasing in several high-income countries. For meat and dairy products, the impact of population dynamics is lower as income and individual preferences play a greater role. In Asia, population growth is responsible for about 60% of the additional consumption of meat. In some countries and regions, the projected growth in total food consumption is the net result of population growth and a partially offsetting decrease in per-capita demand. For example, meat consumption in Africa is expected to expand by only 25%, despite population growth rate of 30% over the coming decade. Similar effects are anticipated for staples consumption in many industrialised countries, however for very different reasons as highlighted in the following sections.

Figure 1.8. Contribution of population to growth in food use



Note: This chart shows for selected regions and commodities the share of the growth in food use accounted for by population growth.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

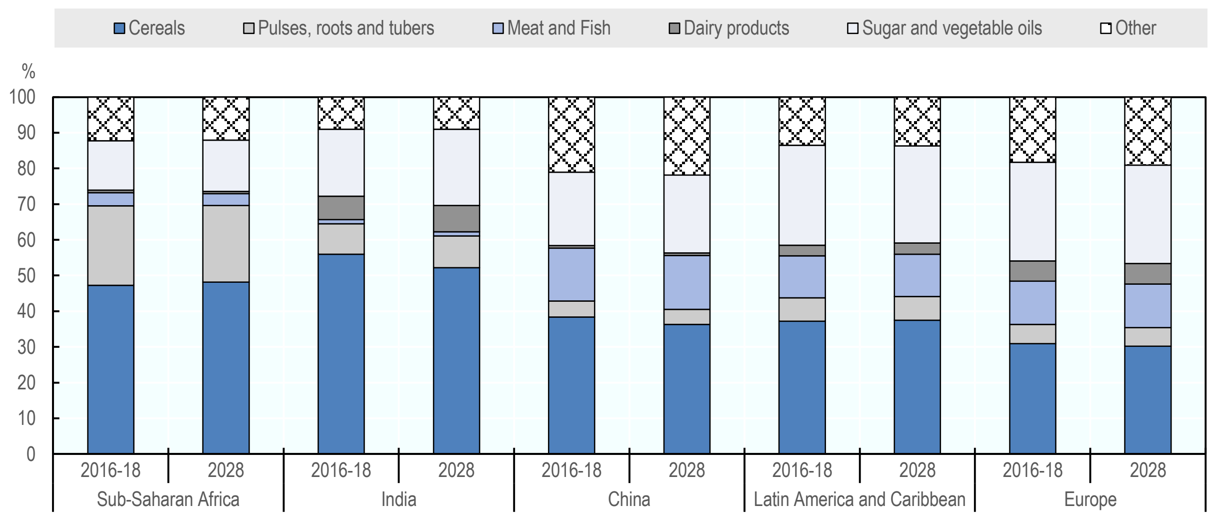
StatLink http://dx.doi.org/10.1787/888933957346

Per capita food consumption: Outlook and drivers

Demographic developments are an important driver of demand growth in many regions, but their effect depends on per capita food consumption patterns in each region. These patterns are determined by consumer preferences and available incomes. Over the outlook period, dietary patterns will be influenced by changes in income, lifestyles and other determinants such as health and environmental concerns. However, regional differences are expected to persist in part because preferences, which have been shaped by culture and tradition, are expected to evolve only gradually.

Figure 1.9 shows the composition of diets across regions over the *Outlook* period in terms of the daily availability of calories per capita by food groups. Important differences in dietary composition exist across regions: staples such as cereals, pulses, roots and tubers represent the biggest share of calorie intake in India and Sub-Saharan Africa, whereas they contribute a smaller share in China, Latin America and Europe.

Figure 1.9. Contribution of food groups to total daily per capita calorie availability



Note: Bars are subdivided into the share of total daily calories per capita attributable to each food group.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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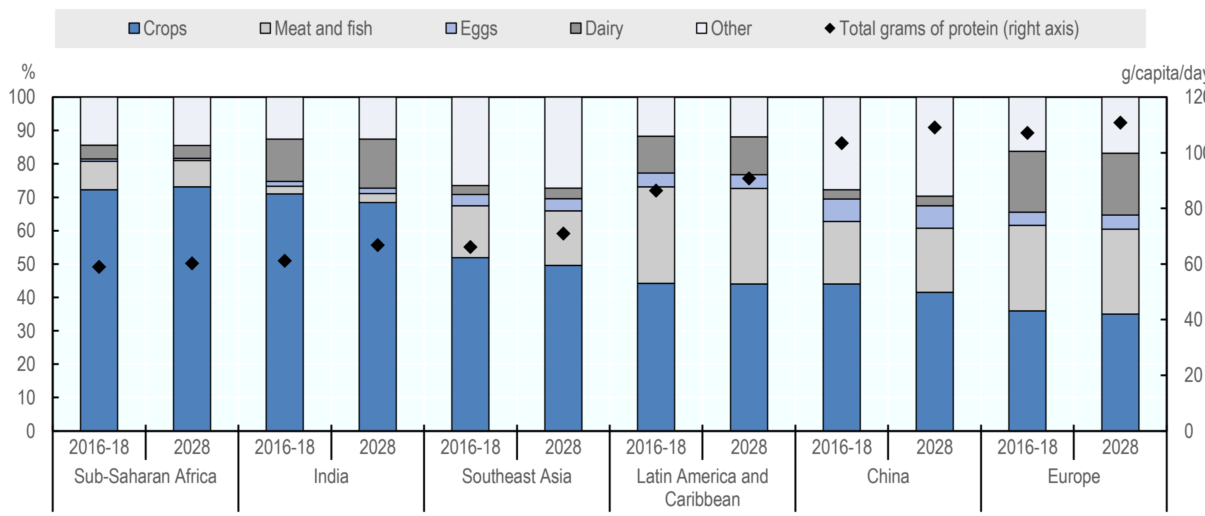
The relative importance of different sources of protein similarly varies around the world (Figure 1.10). Meat and fish account for a large share of protein intake in Latin America and the Caribbean, China, and Europe; but their share is much smaller in India and Sub-Saharan Africa.

Established food baskets across different geographic regions and income groups are expected to evolve only moderately over the medium term, preserving the broader consumption patterns. Consumers in low-income countries will continue to obtain roughly 70% of total calories and protein from staple foods, while only 20% of protein will come from animal sources. People in higher income countries will still consume around 40% of calories as staple foods and obtain over half of their protein from animal sources.

In medium and high-income countries, per capita food consumption of staples such as wheat, rice, roots and tubers has been levelling off or decreasing. The share of cereals in some Asian and Latin American diets is expected to stagnate or diminish, as their consumption is projected to grow at a slower rate than higher value products, such as meat, dairy, sugar or vegetable oil. However, as the mainstays of local diets in these countries, cereals will continue to be important over the medium term.

Despite the broad stability of dietary patterns, some important changes are taking place due to income growth, urbanisation, policies, and growing health and environmental concerns.

Figure 1.10. Contribution of protein sources to total daily per capita availability



Note: Bars refer to the share of the food group in total daily per capita protein intake (left axis); Dots represent the total quantity daily per capita protein intake (right axis); Crops include arable food crops (cereals, edible oilseeds, pulses, roots and tubers, sugar)

Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957384

Implications of changing incomes on diets

Over the coming decade, economic growth is expected to raise average incomes around the world (see Box 1.4 for the overview of economic growth assumption). However, there is a growing concern that the income growth projections underlying the present Outlook are unlikely to be met, with recent data pointing to a more pronounced economic slowdown. The reduced prospects for the near term might translate into weaker growth over the medium term and curb the projected expansion in food consumption more than hereto presented. Furthermore, income growth and distribution will continue to remain uneven across and within regions and countries.

For example, the East and Southeast Asia region is expected to see per capita income grow by 60-100% by 2028. These higher incomes will result in greater demand for meat in the region, with meat consumption rising by 5 kg/capita in China and 4 kg/capita in Southeast Asia over the medium term. This expansion will be largely concentrated in greater poultry and pork consumption, the two meats most widely consumed in those regions. Beef consumption in China is also expected to rise in per capita terms by 0.5 kg/capita over the next decade, bringing average consumption to 4 kg/capita, slightly increasing the share of beef in total meat consumption.

In South Asia, by contrast, income growth will not generate a similar expansion of meat consumption. There, income growth is projected to be associated with greater consumption of dairy products, sugar and vegetable oil. Dairy products and pulses will remain the critical sources of protein. Pakistan is expected to lead global per capita fresh dairy consumption growth, adding 42 kg/capita by 2028 and bringing the country's average annual level to 274 kg/capita, representing nearly 30% of total daily per capita protein availability. Dairy consumption is projected to grow quickly in India as well, and will account for 15% of total per capita protein intake by 2028. Pulses represent the other main source of protein in India.

Food use is estimated to reach 17 kg/capita, accounting for 15% of total protein intake in 2028.

Overall, the role of meat as a source of protein varies across regions at different levels of incomes. These differences are likely to persist as meat is gaining further importance especially in regions that are already key consumers of meat, while elsewhere eating patterns are not expected to change significantly in favour of meat.

Among high-income countries, per capita meat consumption will grow more slowly than in lower income economies. But given relatively high consumption, this translates into a larger absolute increase. Although per capita meat consumption in the United States is expected to grow by only 2%, annual consumption is expected to rise by over 2 kg/capita, bringing the country's intake above 100 kg/capita in 2028, still the highest in the world. In total, United States meat consumption is projected to rise by 4 Mt, accounting for 10% of the global growth in food use. Substantive growth in meat consumption in many medium and high-income countries is expected to widen the gap in per capita meat consumption compared to many low income countries, especially in Sub-Saharan Africa.

Total per capita meat consumption in Sub-Saharan Africa is expected to decline by 0.6 kg, falling to 12.9 kg on average for the region by 2028. Income growth in the region will not develop sufficiently over the medium term to render meat products accessible to a wider population. The consumption decline is projected mostly for sheep, beef and veal, while modest growth is expected for poultry in only a few countries in the region.

At a global level, rising incomes are expected to contribute to significant consumption growth for sugar and vegetable oils. By 2028, global food use of sugar is expected to rise by nearly 2 kg/capita to reach 24 kg/capita. For vegetable oils, the expansion will be comparable, reaching nearly 20 kg/capita by the end of the outlook period. Since both of these changes will affect mostly middle and lower income countries, sugars and fats will contribute a greater share of calories to diets in those regions by 2028.

Urbanisation-led changes in lifestyles contribute to demand for higher-calorie foods

The projected increase in sugar and vegetable oil consumption can be attributed to rising income levels, as well as an ongoing urbanisation of lifestyle in many low and middle income countries. This phenomenon is marked by a structural change in the economy where population increasingly concentrates in urban centres. Migration to urban areas tends to open up new income opportunities, but does not necessarily imply an improvement in the standard of living.

Urbanisation results in longer, more complex, commercial food value chains. Rural to urban migration in the context of urbanisation shifts people away from direct contact with local production and may offer exposure to a wider array of food products, but also introduces the challenge of accessing nutritious food options, which in urban settings may be most easily accessible to higher income groups.[3] Paired with a change in lifestyle that is potentially more time constrained, less centred on the household and thus focused more on convenience, urbanisation is typically associated with greater consumption of convenience foods, processed or prepared outside the home, that tend to be higher in fat, salt and sugar.

With 55% of the global population currently residing in urban settings, a figure that is projected to rise to nearly 60% over the next decade, the relevance of prepared and processed foods will rise accordingly, in turn supporting growth in the consumption of sugar and vegetable oils.

Policies seek to curb the consumption of sugar and fats

The change in diets resulting from a combination of higher incomes and an urban, more time-constrained and convenience-oriented lifestyle has contributed to a rising prevalence of obesity and non-communicable diseases, such as diabetes. In Latin America and the Caribbean, a region that has experienced a significant increase in sugar and vegetable oil consumption, obesity currently affects around one quarter of the population, while about 60% of the population is overweight.

Rising obesity rates and concerns regarding the wider health effects of high sugar and fat consumption have led to policies seeking to curb the consumption of these products. Sugar taxes have been implemented or are being considered in numerous countries, such as Chile, France, Mexico, Norway, South Africa and the United Kingdom. In some cases, such as Chile, such taxes are being paired with new food product labelling requirements that indicate products high in salt, sugar and fat, as well as regulations limiting the youth-targeted advertising of such products. One effect of these measures has been the industry reformulating products to reduce their sugar or fat contents, which in turn may indirectly curb consumption.

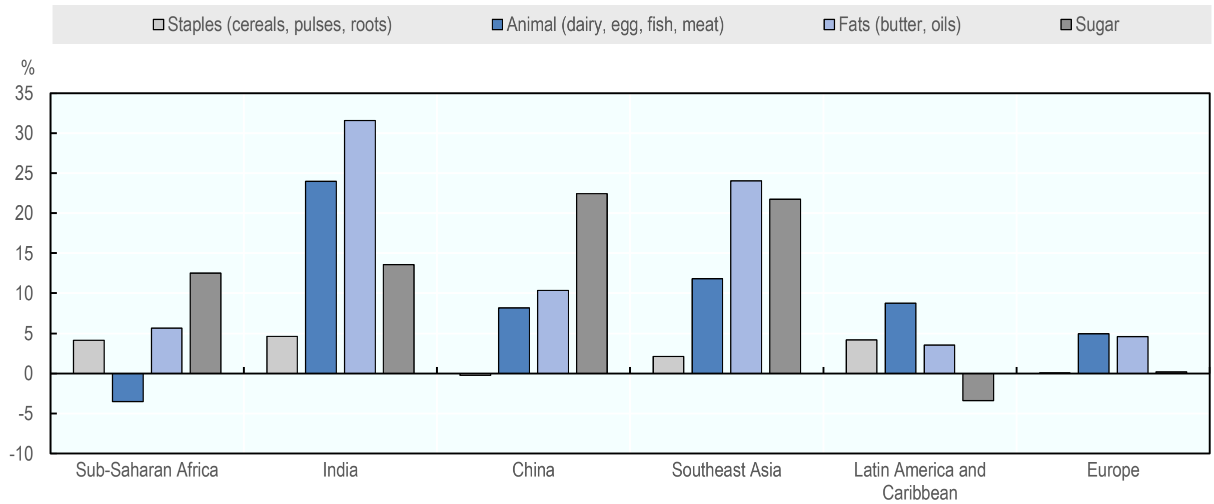
Social factors drive product substitution for healthier and more sustainable alternatives

In high-income countries, growing awareness of health and sustainability issues is increasingly shaping consumer decisions. This effect has contributed to the rising popularity of lean meats, such as poultry. Developed countries are expected to expand per capita poultry food use by nearly 2 kg/capita to reach 31 kg/capita by 2028. By contrast, consumption of beef and veal is projected to decline over the *Outlook* in countries such as Canada (-1.4 kg/capita) and New Zealand (-1 kg/capita). Health concerns will motivate corresponding increases in poultry consumption, with Canada increasing per capita food use of poultry by 1.2 kg/capita by 2028, and New Zealand adding 1.6 kg/capita over the same period. Similar substitutions across meat types are projected for the European Union, Norway, Switzerland and Australia.

Concerns about health and wellbeing are seen as fostering a continued substitution of cooking fats from vegetable oil to butter over the medium term. These considerations, together with environmental concerns regarding palm oil production will contribute to the decline in vegetable oil use by consumers in Canada, the European Union and Norway, where comparable increases in the use of butter are projected to take place. Canada is projected to increase butter consumption by nearly 1 kg/capita over the outlook period, while reducing food use of vegetable oil by nearly 4 kg/capita, despite the price advantage of oils.

Hence, even though large regional differences in dietary patterns will remain, changes in per capita food consumption will take place due to income growth, urbanisation, policies, and health and environmental concerns. Some of these changes are illustrated in Figure 1.11. The change in daily per capita calorie availability will differ across regions, with higher growth rates in India, China, and Southeast Asia relative to other regions; these reflect to a large degree the patterns of income growth. In general, daily per capita calorie intake will grow slowly for staples, but growth rates will be generally higher for animal products as well as for fats and sugar, reflecting the influence of urbanisation and the growing importance of convenience food. Finally, in some regions (e.g. Europe, Latin America and the Caribbean) growth rates for sugar are low or negative, in part due to growing health concerns.

Figure 1.11. Per cent change of food group in daily per capita calorie availability, 2016-18 to 2028



Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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Global outlook for feed demand

In 2016-18, approximately 1.7 billion tonnes of agricultural commodities were used as livestock feed (mainly maize and other cereals, and protein meals derived from oilseeds; the *Agricultural Outlook* only considers commercial feed and hence excludes, for example, pasture, hay and kitchen waste, discussed in Box 1.1). Over the medium term, total feed use is expected to expand by 1.5% p.a., faster than the projected output growth for meat of 1.2% p.a., indicating a further intensification in the livestock sector. The largest share of growth will be taken by cereals, where an additional 156 Mt is expected to be used as feed, compared to a 147 Mt expansion in global food use.

The demand for feed is mainly driven by two factors. First, the demand for products of animal origin (eggs, meat, dairy and fish), which determines the production level of the livestock and aquaculture sector. Second, the structure and efficiency of its production systems, which determine the amount of feed needed to produce the demanded output.

Box 1.1. Is there a trade-off between animal feed and food?

The production of animal products such as meat, dairy products or eggs requires the use of animal feed. Ruminants such as cows, sheep or goats can consume grasses and other plants found on grasslands and rangelands. Non-ruminants such as pigs and poultry, by contrast, cannot live off pastures but require other types of feed. In small-scale "backyard" production systems, this may include kitchen waste; in larger-scale systems, it may include grains and protein meals (derived from oilseeds such as soybeans). The latter can also be fed to ruminants, either to complement a grass-based diet or as main component of the diet (e.g. in feedlots).

Producing animal feed may come at the expense of producing food for humans. This is most obvious when cropland is used to grow feed for animals. But even pastures may to some extent occupy land which could be used for growing food crops.

To quantify such potential trade-offs between food and feed, research at FAO has investigated feed use around the world.[1] Globally, FAO estimates that livestock consumed some 6 billion tonnes of feed in 2010, expressed in dry matter. Of this, 86% was material not edible for humans, such as grass and leaves (46% of the total) or crop residues (19%). Around 13% of the total feed intake consisted of cereals, a figure which corresponded to almost one-third of global cereal production.

Not surprisingly, the data show important differences between ruminants and non-ruminants. Roughages (grass and leaves, crop residues, and silage) represent almost three-quarters of total feed intake, but these are fed almost exclusively to ruminants. By contrast, poultry and pigs together consume two-thirds of all other types of feed. There are also geographic differences. While OECD countries only account for 16% of global roughage consumption, their share of other feed intake is 32%.

The study also estimates that of the more than 3 billion hectares of global pasture, some 685 Mha could in principle be used as cropland, an area which corresponds to around half of current global arable land. In addition, around 560 Mha of global arable land are used to feed livestock through production of crops, principally cereals and oilseeds.

1 Mottet, A., C. de Haan, A. Falcucci, G. Tempio, C. Opio and P. Gerber (2017) "Livestock: On our plates or eating at our table? A new analysis of the feed/food debate", *Global Food Security*, Vol. 14.

Growth in feed demand will expand faster than meat production

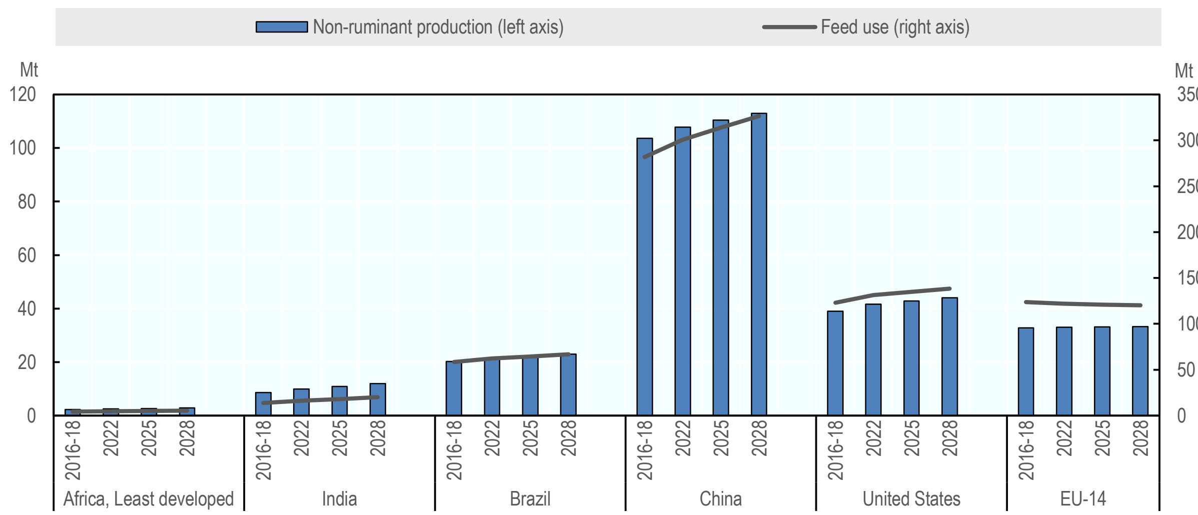
Use of high-energy concentrate feed in China is projected to expand by 61 Mt by 2028 (+1.5% p.a.), the largest volume of growth attributed to a single country over the *Outlook* period. However, other countries are projected to expand feed use at faster rates than China, such as Paraguay (4.0% p.a.); Peru (3.3% p.a.); Viet Nam (3.0% p.a.), Indonesia (2.9% p.a.) and the Philippines (2.7% p.a.). The feed demand growth in these countries relative to the output growth of livestock products indicates further intensification of production. Production of eggs, pork and poultry is projected to expand annually by 1.3% in Paraguay, 2.1% in Peru, and 1.9% in Viet Nam, 2.2% in Indonesia and 2.0% in the Philippines.

The changing structure of livestock production systems influences feed demand

As livestock sectors evolve from traditional or backyard production systems to commercialised production, feeding intensity rises and the overall demand for concentrate feed per unit of output initially grows. With the change in production systems, improvements in feeding efficiency kick in, reducing the per-unit demand for feed again. Paired with the respective growth of the livestock and aquaculture sector, these phases will determine the feed projections of a region in the outlook.

Figure 1.12 depicts the outlook for non-ruminant production and its respective feed use, illustrating the differences in production structures across regions. Growth in feed use for non-ruminant production in regions such as the least developed countries of Africa will expand at a faster rate than production of eggs, poultry and pork, indicating the underlying assumption of a continuing modernisation of production systems in the region. By contrast, in regions such as the United States and the EU-14, which have larger-scale, industrial production systems, feed use expands at roughly the same rate or even at a declining rate relative to non-ruminant animal production.

Figure 1.12. Non-ruminant feed use and meat production over the outlook period



Note: Non-ruminant production includes eggs, pork and poultry. EU-14 represents the pre-2004 members of the European Union excluding the United Kingdom.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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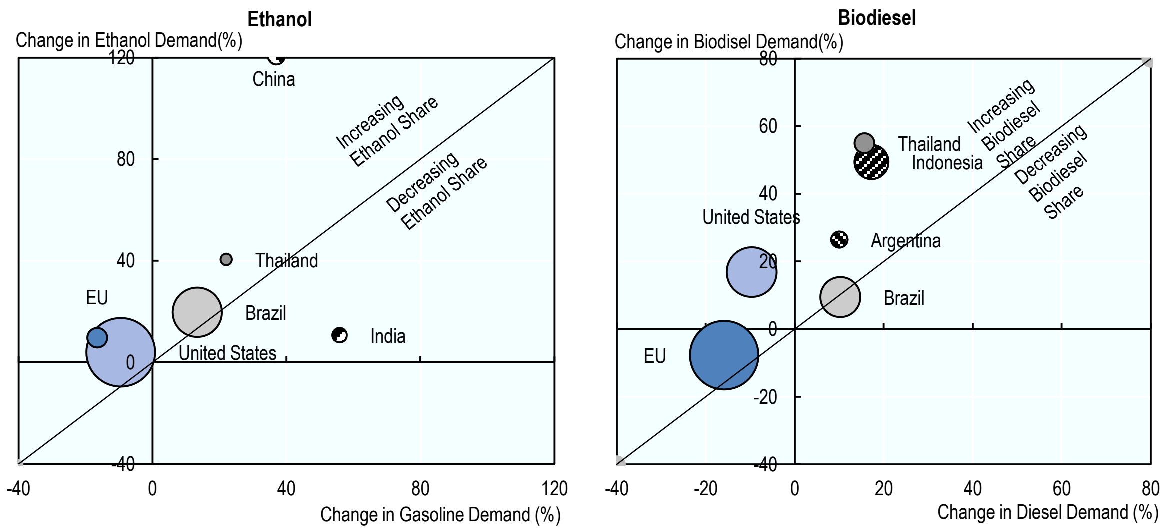
Drivers of biofuel demand: Policy changes and evolving fuel use

Agricultural commodities have become an important feedstock in the transportation fuel sector since the early 2000s when national policies began mandating the use of biofuels in Brazil, the European Union and the United States, where a significant share of maize, sugarcane and vegetable oil are now utilised for the production of renewable fuels. In the European Union and the United States, further expansions will be limited; yet biofuels will continue to expand, based on new or extended mandates in emerging and developing countries (Figure 1.13).

Biodiesel utilisation is expected to rise by 18% or 6.6 Mln L over the coming decade, largely supported by a new mandate in Indonesia that seeks to increase the biodiesel blending rate to 30%. Motivated by high domestic inventories and competitive international prices of vegetable oil, the mandate will be accompanied by a levy collected from palm oil exporters to support the domestic biodiesel sector. These measures seek also to hedge against the potential drop in palm oil imports from the European Union, its most important export destination. As the European Union increasingly directs support towards second generation biofuels and moves away from first generation technology, it is expected to reduce the use of vegetable oil for biodiesel. In parallel, the European Union is expected to experience a decline in total diesel use over the medium term, underpinning a projected 4% decline in biodiesel use.

Figure 1.13. Biofuel demand developments in major regions



Note: The size of each bubble relates to the consumption volume of the respective biofuel in 2018.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957441

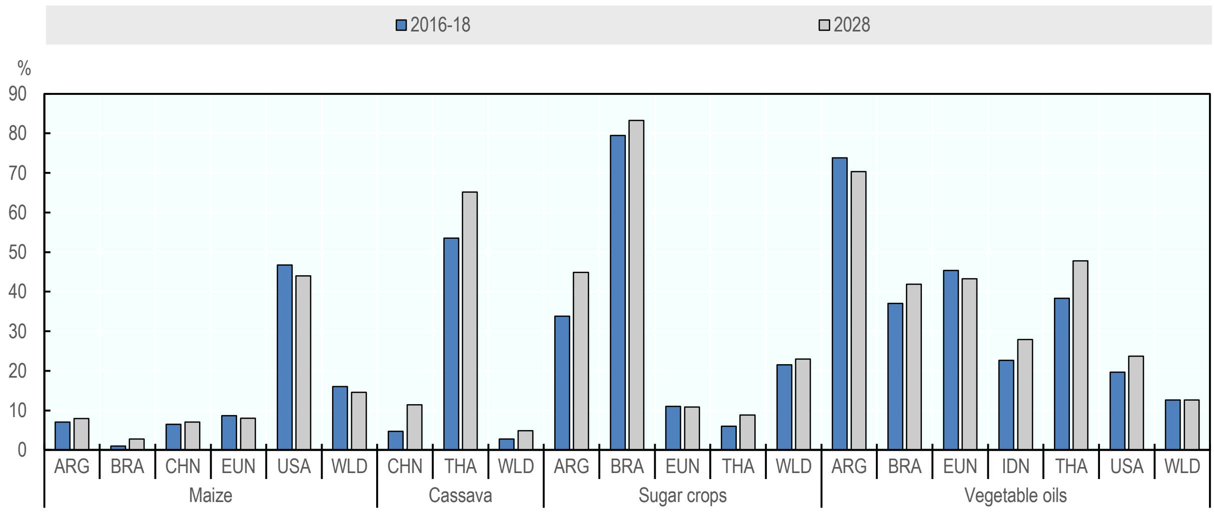
Global use of ethanol is expected to grow around 18% or an additional 21 bln L by 2028 with greater use expected mostly in China (+5.4 bln L). In 2017, the Chinese government announced the goal of a 10% ethanol blending share for 2020, which is expected to be filled through domestic production coming from domestic maize and imported cassava. While the full mandate is unlikely to be reached, strong growth is nonetheless expected.

Brazil, the world's second largest consumer of ethanol, is expected to also add 7.6 bln L as the country's RenovaBio law seeks a 10% reduction in emissions from transport fuel by 2028. This policy will incentivise the expansion of sugarcane for biofuel use over the medium term, motivated in part to counter a ten-year slump in global sugar prices.

Several other countries will continue to apply policies to foster the shift of sugar crops towards ethanol production, which aim to support the domestic sugar cane producers, achieve climate change commitments and to reduce dependency on imported fossil fuels.

Although the use of cassava for ethanol production is still not significant compared to maize or sugarcane, biofuel use is projected to contribute 17 % of total growth in utilisation of cassava, largely accounted for by China's imports of Thai and Vietnamese cassava.

Figure 1.14. Biofuels as a percentage of total use, by main feedstock crops



Note: ARG is Argentina; BRA is Brazil; CHN is China; EUN represents the 27 member states of the European Union (i.e. excluding the United Kingdom); IDN is Indonesia; THA is Thailand; USA is the United States; WLD is the world total. Sugar crops include sugarcane (ARG; BRA; THA; WLD) and sugar beet (EUN, WLD)
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957460

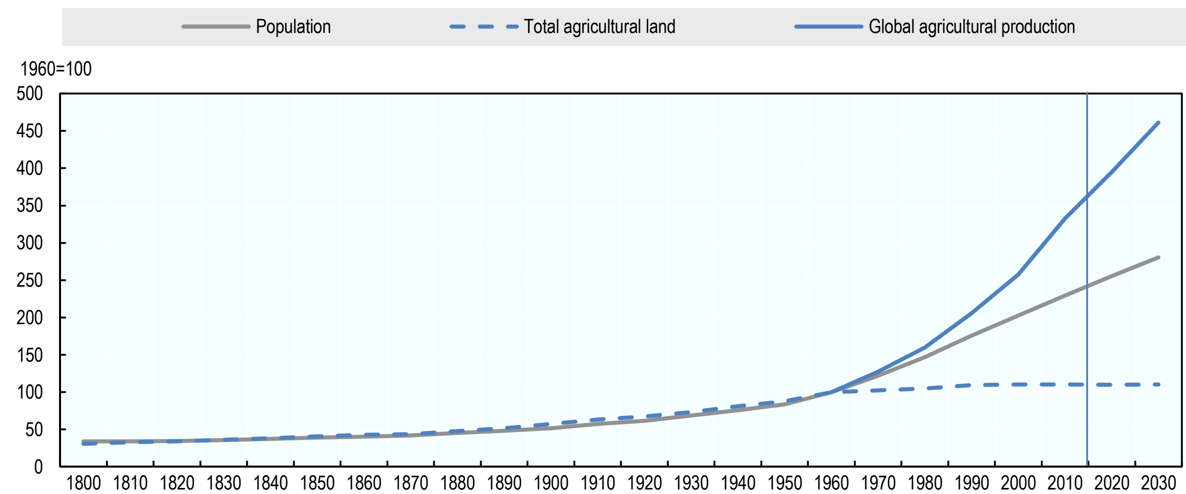
1.4. Production

The growing demand for agricultural commodities raises the question of how the agricultural sector will expand production to meet this demand, and importantly whether it can do so sustainably. Agriculture is a major user of land and water, and has a considerable environmental footprint. For instance, the conversion of natural landscapes to agriculture causes losses of biodiversity and an increase in greenhouse gas emissions, while the intensive use of inputs such as fertiliser and pesticides can affect ecosystems.

Prior to the "Green Revolution" of the mid-twentieth century, crop production grew mainly by bringing additional land into production. (Figure 1.15). Historical estimates suggest that agricultural land use grew proportionately to global population until the middle of the twentieth century. Since the 1960s, the growing application of fertiliser and pesticides, use of irrigation, and improved crop varieties led to drastic yield improvements in many parts of the world. Since then, the majority of incremental production came from higher productivity, i.e. higher yields and cropping intensities, with a much smaller contribution from an expansion of cropland.[4] Ongoing breeding progress, more intense use of high-energy and high-protein feed as well as ongoing improvements in disease control and general production management have at the same time increased productivity in the livestock sector.

Despite global population more than doubling since 1960 and global food production more than tripling, total agricultural land use (for crop production and grazing) is estimated to have increased only by about 10%. For the coming decade, the *Outlook* projects global agricultural production to increase by around 14%, while global agricultural land use is expected to be broadly flat. The *Outlook* thus expects a continuation of the growing intensification of production, resulting in more food per person (Figure 1.16).

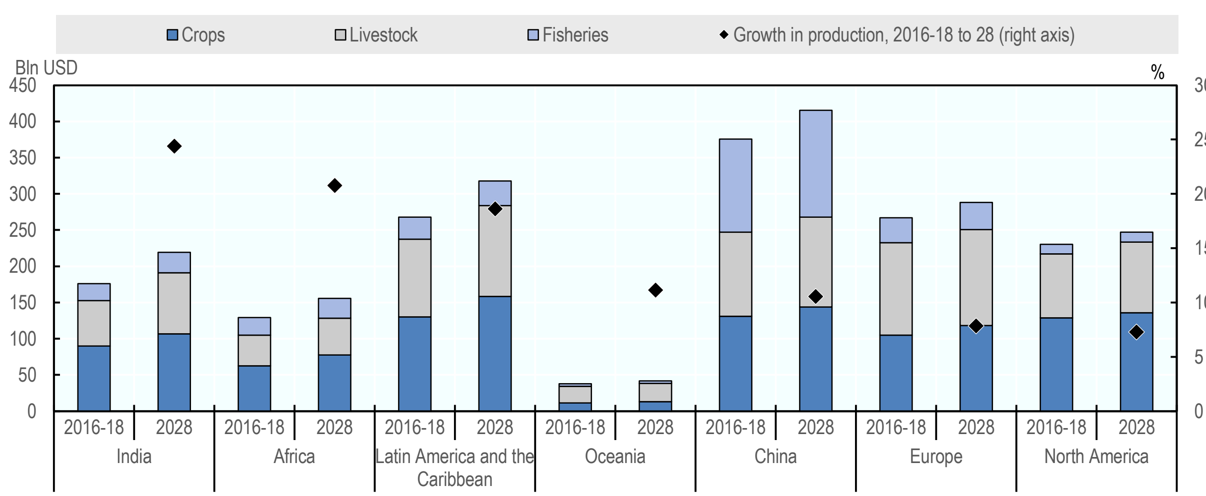
Figure 1.15. Population, agricultural production and agricultural land use in the long run



Note: Population data from Maddison's historical statistics for 1820-1940; UN Population Division for 1950-2030; 1800 and 1810 extrapolated from Maddison. Agricultural (crops and pasture) land data for 1800-2010 from the History Database of the Global Environment (HYDE 3.2), Klein Goldewijk et al. (2017); extended to 2030 using *Agricultural Outlook* projections. Global agricultural production data for 1960-2010 from FAOSTAT (Net Agricultural Production Index); extended to 2030 using *Agricultural Outlook* projections.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957479

Figure 1.16. Regional trends in agriculture and fisheries production



Note: Figure shows the estimated net value of production of agricultural and fisheries commodities covered in the *Outlook*, in billions of USD, measured at constant 2004-6 prices. Europe includes the Russian Federation.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957498

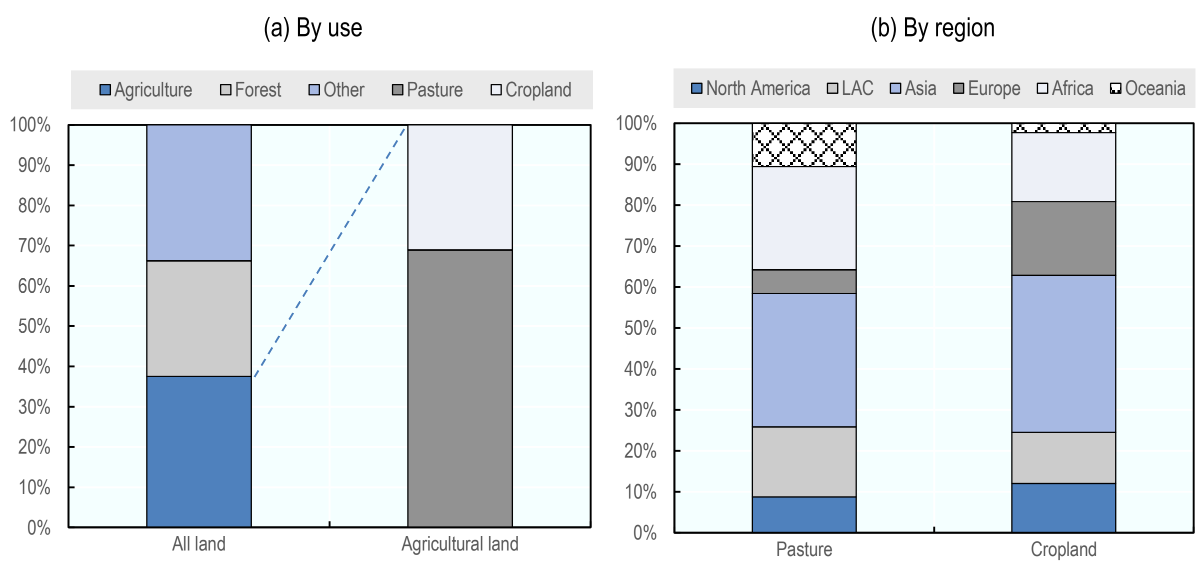
Over the coming decade, production growth will be predominantly located in emerging and developing countries, reflecting greater investment and technological catch-up, as well as resource availability (in Latin America) and, in part, stronger demand growth (in India and

Africa). Production growth is expected to be more muted in North America and Europe, where yields and productivity levels are typically already at high levels, and where environmental policies are limiting the scope for greater output growth.

Agricultural production growth will lead to only minor shifts in global land use

Agriculture currently uses nearly 40% of the world's land (Figure 1.17), of which some 70% are used as pasture. The suitability of agricultural land as pasture and cropland differs by region. Some regions such as Oceania or Africa are constrained to pasture use for large parts of their land, while others (e.g. Europe) are relatively more abundant in land usable for crop production. These differences are determined mainly by agro-ecological characteristics (e.g. rainfall, soil, slope), limiting the substitution between pasture and cropland. Some caution is needed in interpreting pasture area, however, as pasture can be difficult to define or measure precisely.[5]

Figure 1.17. Distribution of global agricultural land



Note: Europe includes the Russian Federation; LAC is Latin America and the Caribbean.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

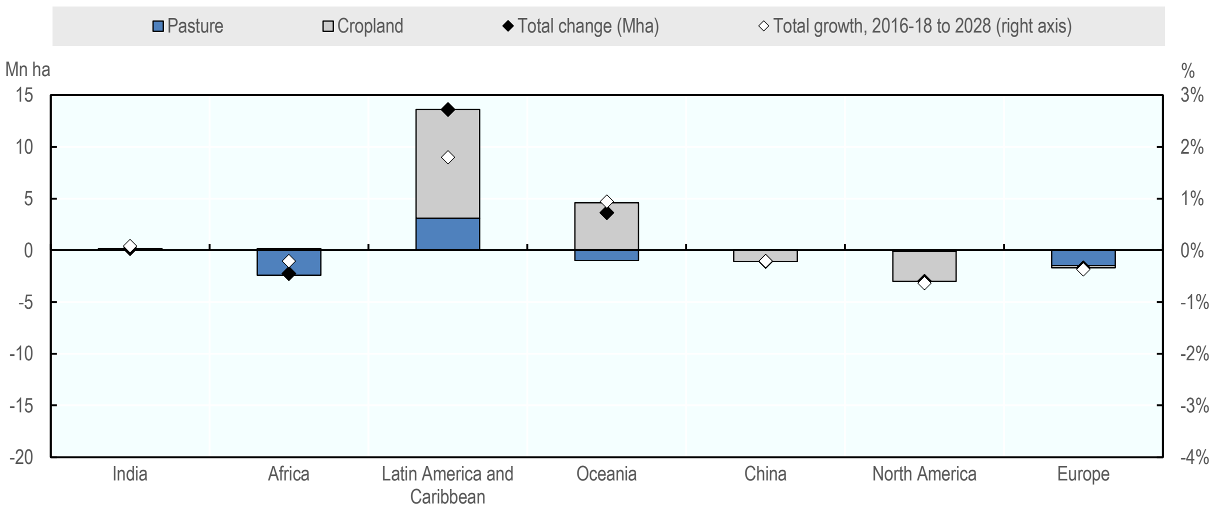
StatLink http://dx.doi.org/10.1787/888933957517

In line with trends observed over the past decade, global agricultural land use is expected to remain at current levels during the coming decade as an increase in cropland offsets a decrease in pasture. However, trends in land use, and their underlying determinants, differ around the world (Figure 1.18).

Both pasture and cropland use are projected to expand in Latin America and the Caribbean. Mostly low-cost, large-scale commercial farms in the region are expected to remain profitable and to invest into the clearing and cultivation of new land, despite the projected low-price market over the coming decade.

Total agricultural land use is not expected to expand significantly in Africa, despite substantial land availability in Sub-Saharan Africa. The farmland expansion will be mainly constrained by the prevailing smallholder structure, the presence of conflict in land-abundant countries, the loss of agricultural land to degradation and other uses such as mining and urban sprawl. Some pasture land is expected to be converted into cropland in the region, e.g. Tanzania, reflecting the development of agricultural area by commercial farms.

Figure 1.18. Change in agricultural land use, 2016-18 to 2028



Note: Europe includes the Russian Federation.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.
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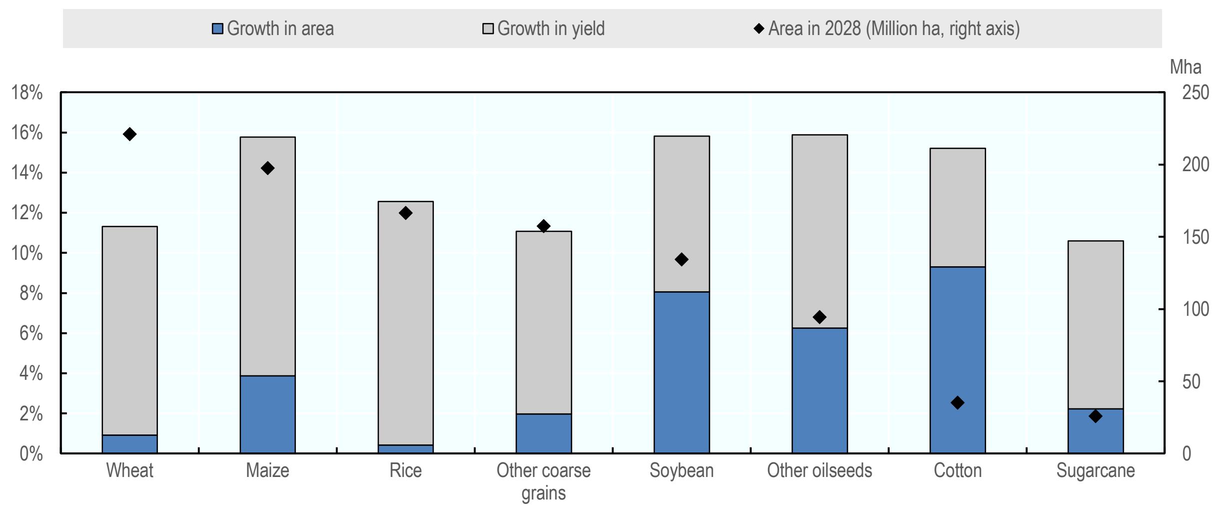
Higher crop production expected mostly through improved yields

Over the coming decade, global crop production is expected to expand by 384 Mt for cereals, 84 Mt for oilseeds, 41 Mt for roots and tubers, 19 Mt for pulses, and 3 Mt for cotton. The growth in crop production will be achieved mostly through investments into yield improvements in the case of cereals and palm oil, and through a combination of area expansion and yield growth for oilseeds, cotton and sugarcane.[6]

For wheat, production will expand in particular in the Black Sea region. In the Russian Federation, government-supported investments in infrastructure and agricultural technology such as improved seeds have increased productivity in recent years, a trend which is expected to continue. The focus on strengthening domestic agriculture seems in part related to the sanctions put in place since 2014, which have limited imports of basic commodities from the United States and the European Union. Paired with a weaker currency and an improved domestic capacity to supply inputs, the Russian Federation's exports of wheat have become competitive on global markets (see trade section for more detail).

Production of maize and soybeans is largely dominated by the Americas, and production growth will come both from changes in the land use as well as investments to improve yields. In Argentina and Brazil, the ongoing practice of double cropping of maize and soybean is expected to raise output through more intensive use of already cultivated land. By contrast, in North America, the expansion of harvested area for maize and soybeans happens almost exclusively through substitution with other crops. Growth rates of North American yields are expected to be driven mostly by breeding progress, as farms tend to operate at the production frontier. Figure 1.20 illustrates the projections for area expansion and yield improvements across different regions. Despite higher yield growth in lower-yielding regions, wide yield disparities will remain by 2028.

Figure 1.19. Growth in crop production



Note: Figure shows the decomposition of total production growth (2016-18 to 2028) into growth of global area harvested and growth in global average yields.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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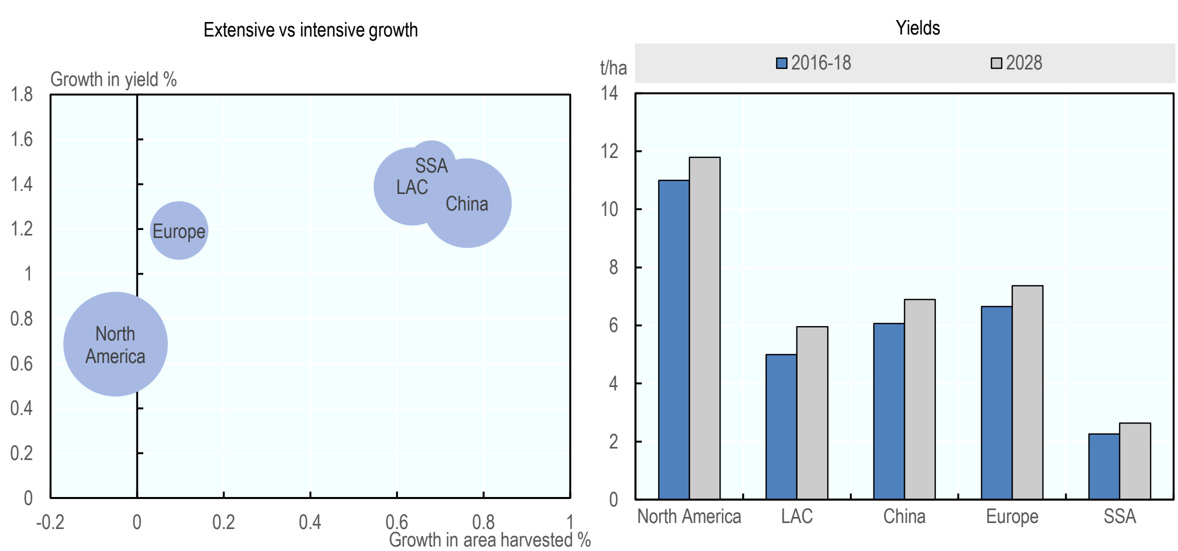
Figure 1.20. Maize production



Note: In the left panel, the size of the bubbles is proportional to maize production in 2028. LAC is Latin America and the Caribbean; SSA is Sub-Saharan Africa.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957574

Yields for other crops will also continue to vary widely around the world. This is in part due to different agro-ecological conditions, but it also reflects yield gaps caused by lack of access to improved crop varieties, fertilisers and other inputs.[7] Since the beginning of the "Green Revolution" in the 1950s, the use of such inputs had grown strongly in much of Asia and Latin America, while technological change in Sub-Saharan Africa has historically been much slower. Fertiliser use per hectare of arable land in East Asia, South Asia, and Latin America is respectively 20, 10 and 9 times greater than that in Sub Saharan Africa.[8] In recent years, however, the use of fertiliser and other inputs (in particular herbicides) has been growing in several countries in the region.[9] Continued efforts to develop locally adapted improved crop varieties and to implement optimised management practices should further increase yields in Sub-Saharan Africa. In regions where the use of fertiliser and crop protection chemicals is already widespread, continued yield growth is expected to come mostly from improved varieties.[10]

Box 1.2. Innovations in plant breeding

Since the Green Revolution, plant breeding innovations such as semi-dwarf wheat and rice varieties and new genetic sources of pest and disease resistance have greatly improved the yield, quality and resilience of agricultural crops. New innovations in plant breeding have emerged in recent years and can help meet these continuing needs.

A first innovation is the extension of hybridisation to more species. When two inbred lines are crossed, the resulting seed has increased vigour, yield and yield stability, a phenomenon known as *heterosis*. In the past, hybridisation was only feasible for a few crops, notably maize. New techniques now enable the development of hybrid varieties for wheat and rice, among others. For instance, work is underway on wheat hybrids that are less vulnerable to changes in climatic conditions. Recent work on a Japonica rice hybrid also aims to deliver hybrid plants that produce cloned seeds, which could reduce seed production costs and encourage the uptake of new varieties by farmers.[1]

Traditional breeding requires vast numbers of plants over many years to select improved varieties. Recent 'genomic selection' techniques use computational models and molecular markers to predict and identify when certain genes are expressed, thereby improving the efficiency of selection. Genomics can also be used to explore the presence of beneficial genes in underexploited gene banks.[2]

Even newer techniques such as CRISPR can generate targeted mutations quickly and easily, and can therefore be used to speed up the development of useful agronomic traits.[3] Researchers recently used such techniques to create a wheat variety resistant to powdery mildew (a fungal pest). CRISPR is also being used to speed up the introduction of viral resistance in plants.

In several important crops such as soybeans, rice and wheat, the photosynthesis process is relatively inefficient, limiting plant growth. Researchers have recently used genetic engineering to change the photosynthesis process in tobacco (chosen as a model species as it is easy to modify). This resulted in 41% more biomass, which suggests that important yield gains could be possible in important food crops as well.[4]

But such developments in the lab are only the first step in a long journey to the farm. New characteristics need to be available in high performing varieties that are generally well adapted to the agro-ecological region where they will be grown. This requires breeding, multiplication and distribution infrastructure for finished varieties. This, in turn, requires the trusted provision of authentic, traceable, high-quality seed typically ensured through variety registration, seed certification and royalty collection schemes. The OECD Seed Schemes forms a key part of the international regulatory framework that ensures that high quality seed reaches farmers.[5] Expanding the access to breeding innovation for farmers also remains a challenge. Estimates indicate that the 13 leading global seed companies together reach no more than 10% of the world's 500 million small farms.[6] Hence, the innovations listed here may not immediately show up in farmers' fields; but they are of promising long-term potential nonetheless.

1. Khanday et al. (2019), "A male-expressed rice embryogenic trigger redirected for asexual propagation through seeds," *Nature* 565, 91-95.
2. Yu et al. (2016) "Genomic prediction contributing to a promising global strategy to turbocharge gene banks," *Nature Plants* 2, 1-7.
3. Schaart, J. et al. (2015), "Opportunities of New Plant Breeding Techniques," Wageningen University and Research, http://edepot.wur.nl/357723.
4. South et al. (2019) "Synthetic glycolate metabolism pathways stimulate crop growth and productivity in the field," *Science* 363, 6422.
5. See http://www.oecd.org/agriculture/seeds/
6. Access to *Seeds Index*, https://www.accesstoseeds.org/.

The outlook for palm oil, cotton and sugarcane is influenced to a larger degree by concerns related to land availability, investments and sustainability.

Global production of cotton is projected to grow by 10% by 2028. Global cotton yields have been flat since 2004, as several countries struggle with pest and water problems. Because of these continuing difficulties in raising yields, the expansion of cotton production will come in large part through greater land use.

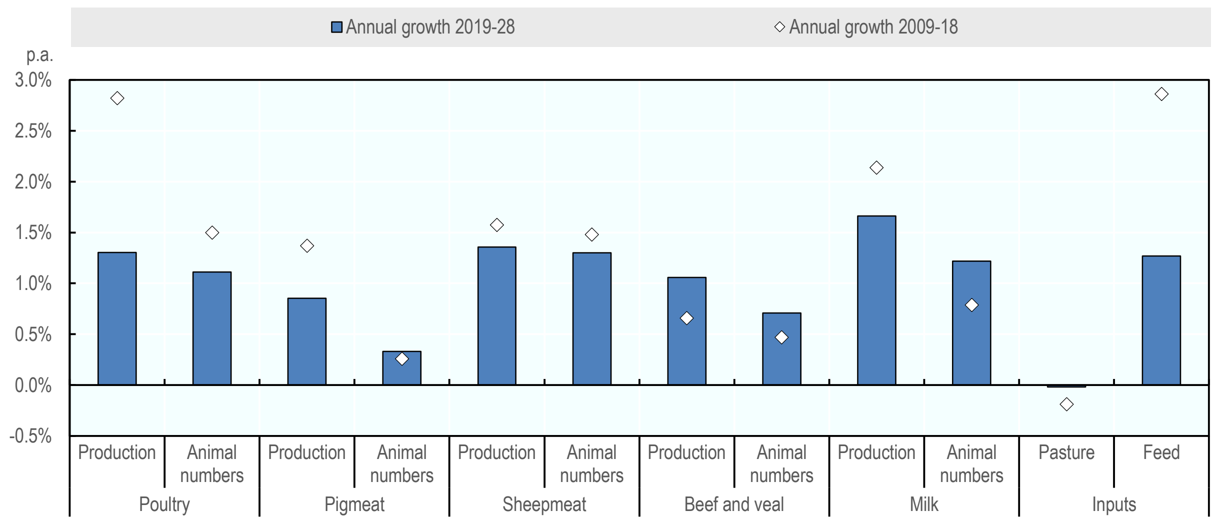
Expectations of declining real prices and ongoing sustainability concerns in some markets will limit further investments in the palm oil sector in major producing countries. Replanting of trees and cultivation of new plantations is expected to slow significantly, resulting in a production expansion of only 9 Mt by 2028, compared to growth of 27 Mt in the previous decade.

Despite continuously low sugar prices, the global production of sugarcane is expected to expand by about 13% over the outlook period, responding to ongoing growth in sugar and (especially) ethanol demand across the world. While the replanting of sugarcane will be slow in the main producer country, Brazil, sugarcane production will grow strongly in India (in part due to public support to the sector).

Growth in livestock production varies in intensity across regions

Over the outlook period, livestock production is projected to expand by nearly 15%, based on a range of growth factors. In most countries the larger output of meat, milk and other livestock products will be achieved by a combination of increasing the number of animals and improving the average output per animal per year. More intensive meat production will occur through higher slaughter weights per animal and shortening the time to finish an animal for slaughter. Both of these dimensions can be influenced by animal breeding, the use of higher-quality feed, and improved management practices.

Figure 1.21. Growth in global livestock production



Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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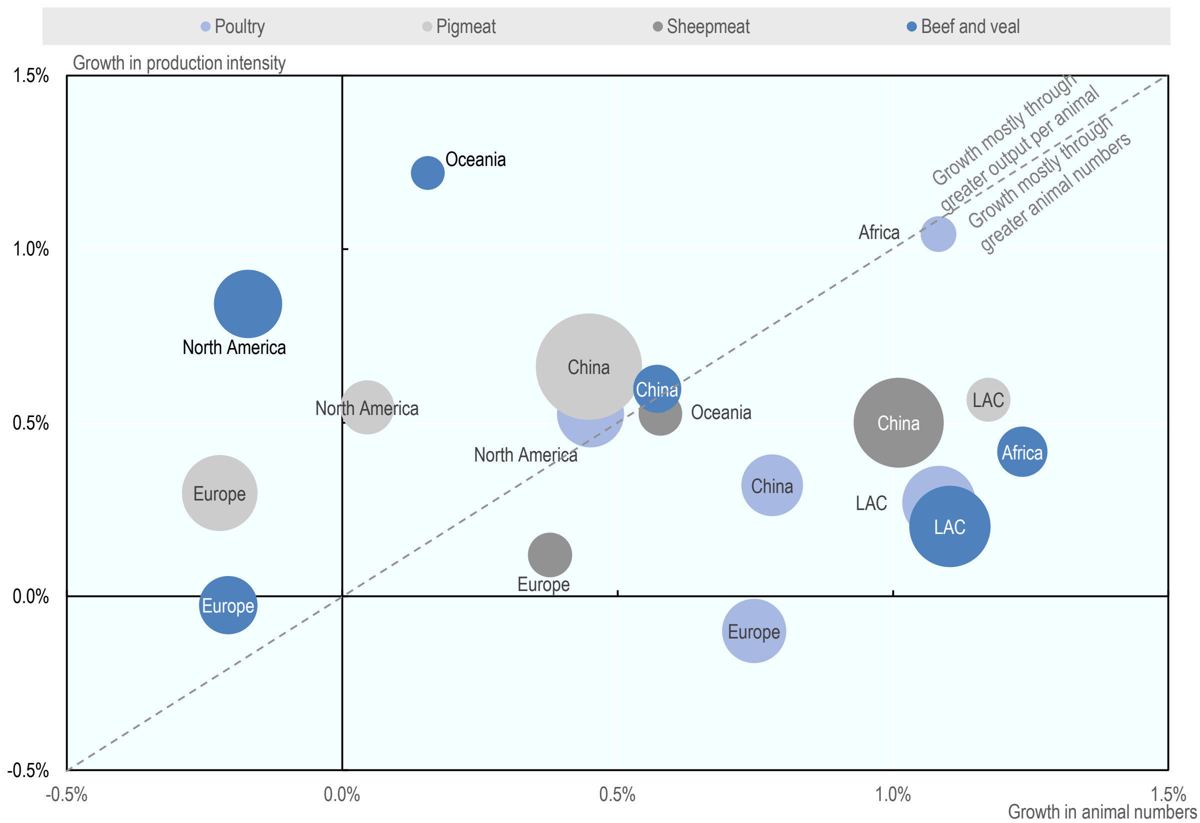
For poultry and sheep meat, global production will grow more or less in line with the growth in animal numbers, while output is expected to grow faster than animal numbers for pigmeat, beef and veal, and milk (Figure 1.21). At the global level, the growth in livestock production will be achieved with declining pasture land, but with robust growth in the use of animal feed. The relative role of greater animal numbers and higher production intensity (understood here as output per animal) will differ not only by livestock product but also by region; in general, animal numbers will grow faster in emerging and developing regions than in Europe or North America (Figure 1.22).

Poultry production is expected to increase by 20 Mt, accounting for roughly half of the total increase in meat production over the coming decade. Poultry production is expected to intensify, taking advantage of favourable feed prices, while simultaneously expanding the production base. Rising poultry production in China and Latin America is expected to account for nearly 40% of the global expansion of poultry meat and will be mostly related to growing animal numbers. In Europe, the growth in poultry meat production per animal has slowed down in recent years and production is expected to remain flat in the coming years.

Sheep meat production is much lower than the other meat types at the global level, but is projected to show strong growth of 14% (+2 Mt). Growing incomes in China and growing population in Africa will support demand growth, much of which will be sourced locally. Since sheep production is typically pasture based, growth comes mainly from breeding progress and expansion of flocks. In Africa (not depicted in Figure 1.22), sheep herds are expected to grow by nearly 2% p.a., while production per animal is expected to be flat as breeding progress has so far been limited in the region.

Figure 1.22. Sources of meat production growth, by region



Note: Production intensity is defined as total annual output divided by the number of animals at the end of the calendar year. The size of each bubble is proportional to the region's share of global production of each meat type in 2028. Regions accounting for less than 5% of the total are not shown. One outlier (sheepmeat in Africa) is not shown.

Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957612

Beef and veal production is expected to expand by about 9 Mt by 2028. The world's largest producing regions, Latin America and the United States, will contribute more than half of global growth. The combination of relatively low feed prices and growing demand for beef and veal is expected to stimulate an intensification of production in North America and Oceania.

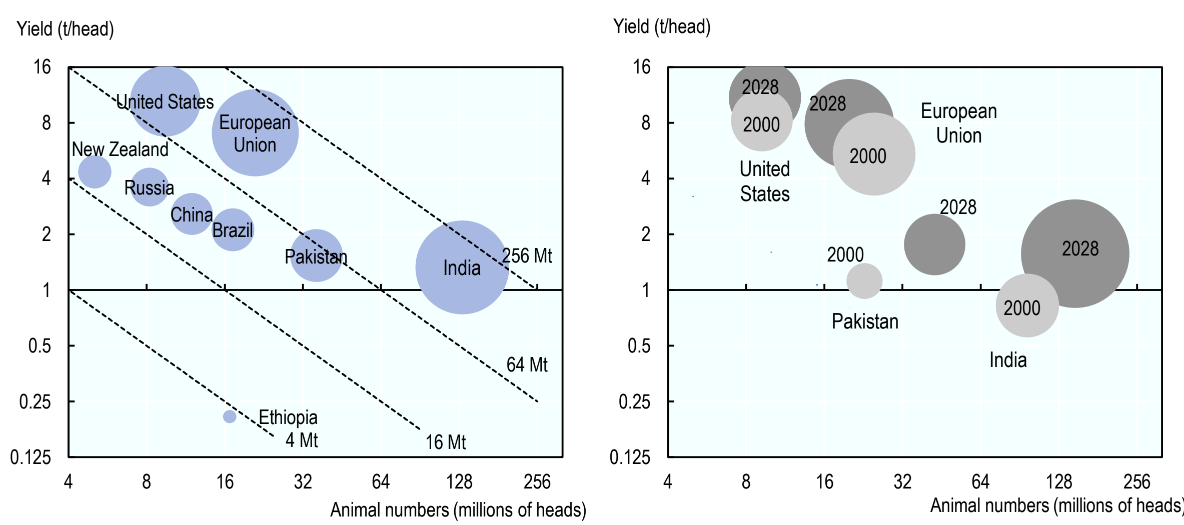
Pigmeat production is projected to grow by 11 Mt by 2028, an expansion that will be largely concentrated in China, which will account for 42% of global growth. In China, two-thirds of production growth is expected to come from increasing production intensity. Over the past decades, the country has moved away from backyard production to commercial operations. The recent outbreaks of African Swine Fever are expected to lead to a further shift in production towards larger, more productive operations (as discussed in more detail in the meat chapter), which should raise the average output per animal. Growing production intensity will thus be the dominant trend in the global pork industry. However, in Latin America, which historically played a much smaller role in pig meat than in poultry or beef, growing animal numbers are expected to be more important as the region seeks to respond to fast-growing demand in Asia.

Animal husbandry in Africa is expected to remain largely dependent on small-scale producers. Intensification is constrained by structural issues such as a lack of investment capital, the limited availability of feed, and environmental factors such as desertification in North Africa. These factors are particularly pronounced for ruminant (beef and sheep meat) production, where output per animal is expected to remain stagnant in the coming years. However, poultry is a notable exception. In some countries, such as South Africa and Tanzania, the modernisation of the poultry supply chain has resulted in intensified production, which is expected to lead to further growth in the next decade.

Dairy is expected to be the fastest growing livestock sector over the next decade. The sector is responding to strong demand, especially for fresh dairy products in Asian countries, but is also driven by ongoing favourable prices for processed dairy products, such as butter, cheese and milk powders. In most dairy-producing regions, production of butter and cheese will expand, utilising milk produced through intensified feeding of a steadily growing dairy herd.

Despite projected global improvements in yields, dairy productivity tends to vary strongly around the world (Figure 1.23). For instance, milk yields in India, the world's largest producer, are currently only one-eighth of the level achieved in North America, another major supplier of milk and dairy products. Strong growth of dairy production in India will partly come from an increase in milk yields (through better feeding practices and better genetics), but the yield gap between India and North America is expected to remain wide.

Figure 1.23. Dairy production, yield, and animal numbers



Note: Yield is milk production in tonnes per head, including non-cow milk. Animal numbers include non-cow herds. Both axes are shown on a logarithmic scale to allow the comparison of producers who vary considerably in scale. The size of the bubbles indicates total milk production (including non-cow milk). The downward-sloping lines connect all combinations of yields and inventories which result in the same level of production (in Mt). 'European Union' refers to EU-27 in all years.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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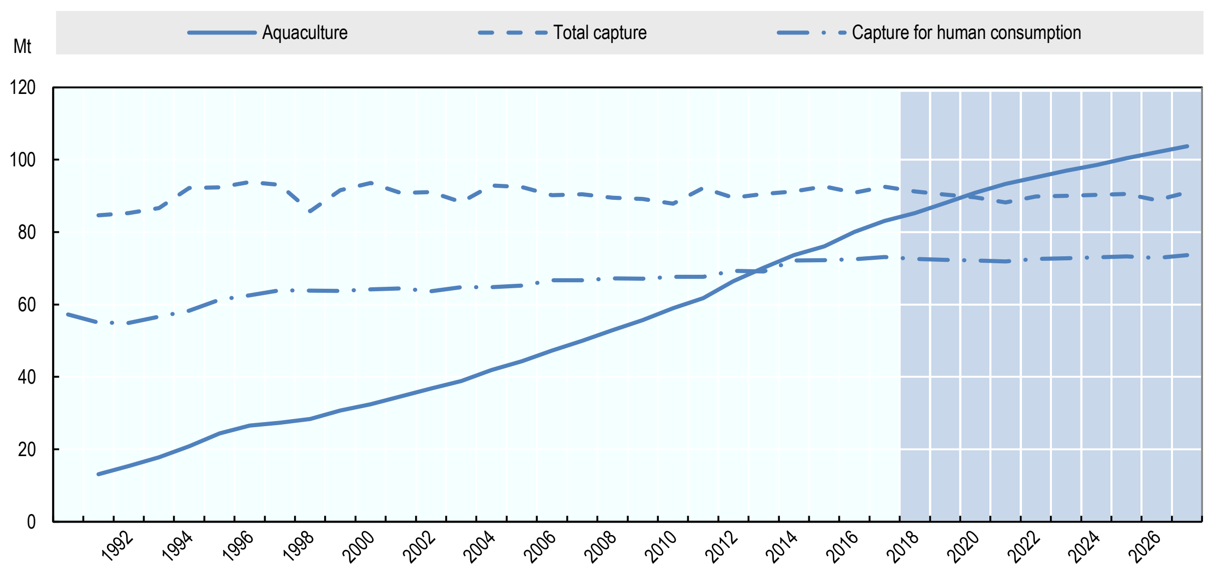
Aquaculture expected to overtake capture fisheries in coming years

Fish and seafood production today has two equally important sources – capture and aquaculture. Until the 1990s, almost all fish and seafood was obtained through capture fisheries, since then, the importance of aquaculture has grown steadily, notably in China. Currently, aquaculture accounts for 47% of total production and is expected to continue its rising trend, while capture fisheries production has remained relatively flat over the past 20 years any further expansion is expected to be relatively limited. As a result, over the course of the *Outlook* period aquaculture is expected to overtake capture fisheries as the most important source of fish and seafood worldwide.

Figure 1.24. Aquaculture and capture fisheries



Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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Greater efficiency in aquaculture production is anticipated over the *Outlook* period, especially by reducing the amount of fishmeal or fish oil needed to produce a given quantity of farmed fish, including by using substitutes such as protein meal, insects, or algae in fish feed rations. The relative share of feed derived from wild fish species (e.g. anchovies) is expected to continue falling over the next decade.

Impact of policies on outlook

Public policies exert a strong influence on agricultural markets. Agricultural support policies such as subsidies, guaranteed minimum prices or import tariffs can stimulate production, albeit in an inefficient way and, depending on the circumstances, potentially at the expense of trade partners. For this reason, the use of such support measures is governed by the World Trade Organization's Agreement on Agriculture, which has been in force since 1995. This agreement puts upper limits on the use of the most distortionary policies, but still leaves considerable room for such policies. Historically, support to farmers was mostly provided by high-income countries, but in recent years, such support has also become widespread in a number of emerging countries, in some cases to support an objective of domestic self-sufficiency in certain products.[11] This is the case in the Russian Federation, for instance, where the government sets production targets for several agricultural commodities (including cereals, meat, sugar, vegetable oil, and dairy) and provides various forms of financial support to farmers. Similarly, within the ASEAN group of Southeast Asian economies, almost all have some form of self-sufficiency targets, most commonly for rice.[12]

Given agriculture's considerable use of natural resources and its contribution to greenhouse gas emissions, the coming decade is likely to see more policies to improve environmental sustainability, possibly constraining output growth. For instance, China's 13th Five-Year Plan (2016-2020) aims to improve the efficiency and sustainability of its fisheries and aquaculture industry leading to a likely reduction in Chinese capture fisheries and a smaller increase in aquaculture than would have been the case otherwise. As China currently accounts for nearly 40% of global fish production, these stricter policies also imply lower growth in global production (as discussed in more detail in the Fish and Seafood chapter).

Agricultural support measures and sustainability policies have a visible and direct effect on output. However, other policies may have greater impacts but may act with a longer delay. This is particularly the case for measures to stimulate public and private investments in agricultural research and development (R&D), which are in the long-run the most important determinant of productivity growth in crop and livestock agriculture. This topic is discussed in more detail in the Risks and Uncertainties section.

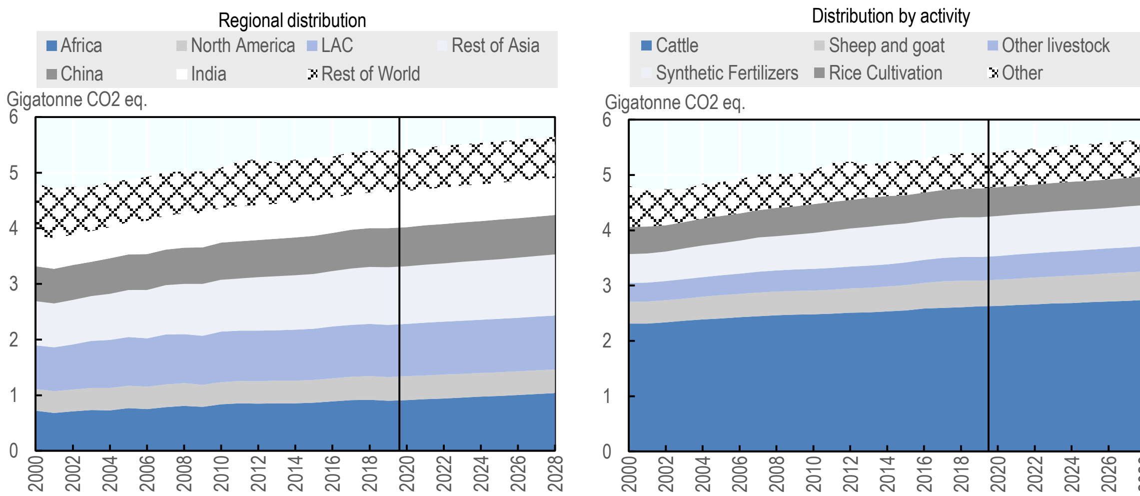
Implications for greenhouse gas emissions

Greenhouse gas emissions from Agriculture, Forestry and Other Land Use (AFOLU) are estimated at 24% of the global total. Direct emissions from agriculture account for 11% of global emissions, but agriculture also indirectly causes much of the emissions from land use change, for instance when expanding agricultural land use leads to deforestation or to the draining of peatland.[13] Livestock (and in particular ruminants such as cattle, sheep and goats) account for two-thirds of agriculture's direct emissions (e.g. through enteric fermentation and emissions from manure), with an additional important indirect effect on land use. Synthetic fertilisers and rice production are two other important contributors.[14]

Over the outlook period, and assuming no change in current policies and technologies, projections imply a growth in direct GHG emissions of 0.5% p.a. This is in line with the historical path of direct emissions, which similarly increased by 0.5% p.a. between 1990 and 2016, below the growth rate of agricultural production over the same period (at 2.7% p.a.). This differential implies a declining carbon intensity over time, although it has not been enough to achieve an absolute decoupling of emissions from production.

Almost half of the growth in direct emissions is expected to come from cattle, with another 15% coming from small ruminants (sheep and goats). Geographically, most of the increase in direct GHG emissions from agriculture is projected to come from the developing world, with Africa alone accounting for more than 40% of the increase, and Asia (including China and India) accounting for another 45%. The large contribution of the developing world is explained both by their higher growth rates of agricultural production and by the extensive, pastoral livestock systems, which lead to relatively high GHG emissions per unit of output.[15]

Figure 1.25. Direct GHG emissions from agriculture



Source: OECD/FAO (2018), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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Between 2000 and 2010, the direct emissions shown in Figure 1.25. made up slightly more than half of total agricultural GHG emissions, with the remainder coming through land use effects, mostly burning of biomass and deforestation. Over time, these indirect emissions have been declining, in particular thanks to a reduction in deforestation rates. The future evolution of these indirect emissions is not modelled in this *Outlook*.

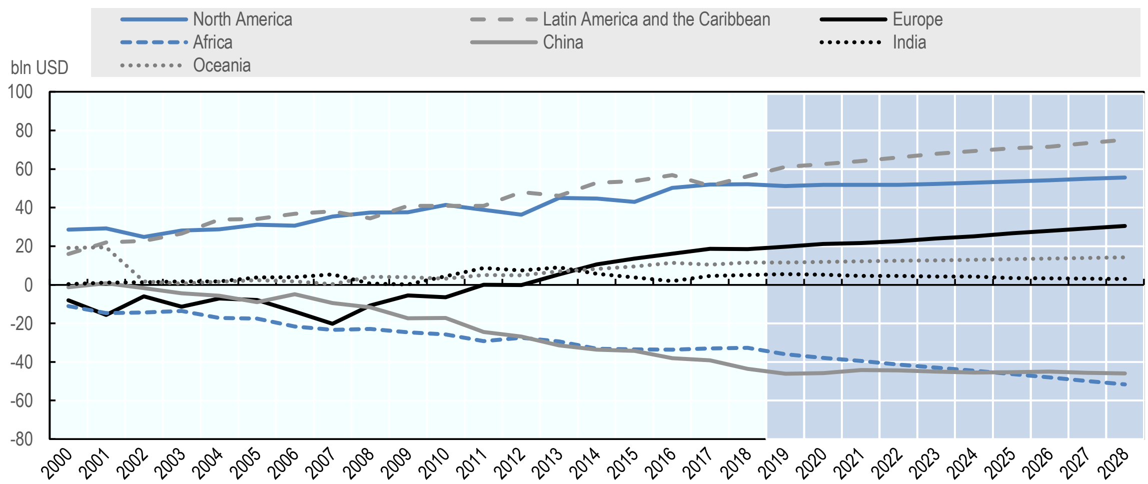
Several options exist to mitigate emissions from agriculture. These include carbon pricing, policies to reduce or prevent deforestation, technological options to reduce the emissions intensity of agricultural production practices, changes in diets away from products with a high emissions footprint, and initiatives to reduce food loss and waste.[16] These policy options need to be assessed carefully given the complex interactions between the environment, rural livelihoods, and food security and nutrition.[17]

1.5. Trade

The regions where agriculture is most productive are not always the places where population (and hence demand) are concentrated. Agricultural trade is therefore essential for food security in some regions, and an important source of income in others. Over time, agricultural trade has allowed an increasing differentiation between net exporting and net importing regions, with agricultural exports often originating from a relatively small number of countries while agricultural imports are typically more dispersed.

Since the early 2000s, growth in agricultural trade has been supported by a lowering of agro-food tariffs and trade-distorting producer support, and by strong economic growth in China.[18] Over the coming decade, agricultural trade will continue growing but at a slower pace, as global demand growth, and Chinese import growth in particular, slows. However, the broader trend of continuing differentiation between net exporting and net importing regions is expected to continue in the coming decade (Figure 1.26).

Figure 1.26. Agricultural trade balances by region, in constant value



Note: Net trade (exports minus imports) of commodities covered in the *Agricultural Outlook*, measured at constant 2004-06 USD. Europe includes the Russian Federation.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

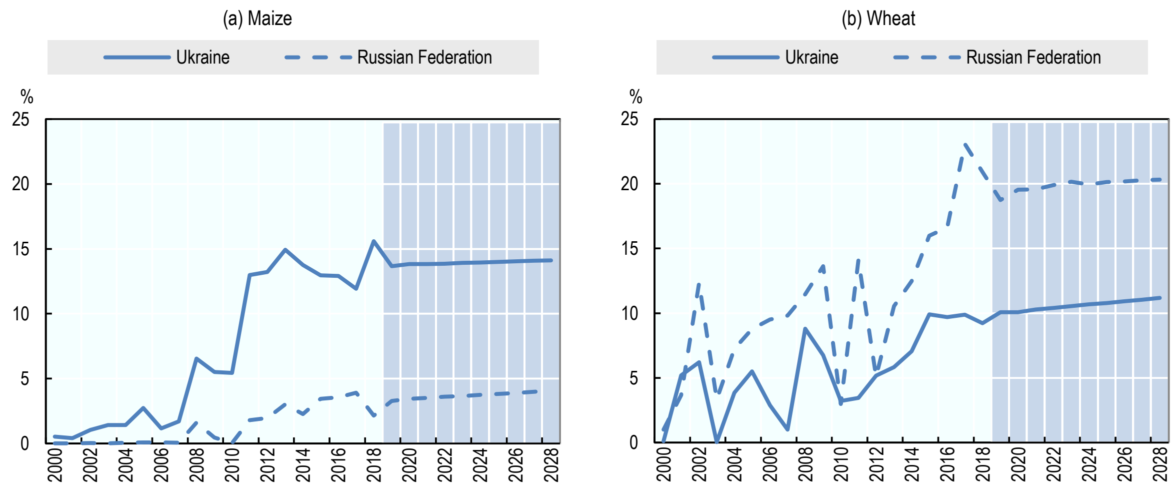
StatLink http://dx.doi.org/10.1787/888933957688

Throughout the 2000s, the Americas in particular have strengthened their position as global suppliers of agricultural commodities such as maize, soybean, and meat. Over the coming decade, Latin America and the Caribbean are expected to see increasing exports, while export growth in North America will be more muted, in line with the projected trends for agricultural production. Oceania has traditionally been a net exporter of agricultural commodities, but total exports (after adjusting for price changes) have been broadly flat over the past two decades, a trend which is not expected to change much.

Europe (which also includes the Russian Federation and Ukraine) has moved over time from being a net importer of agricultural commodities to a net exporter, in part due to a stagnating population and flat per capita consumption, which limits domestic demand. Production growth has also contributed to the improved export performance, in particular for Ukraine and the Russian Federation, which have grown in the span of a few years into competitive exporters of maize and wheat respectively, due to significant productivity improvements and favourable exchange rate movements (Figure 1.27).

Among the regions with a negative agricultural trade balance, net imports have grown in China and Africa, albeit for different reasons. In China, strong economic growth stimulated food demand, leading to a surge of imports in the 2000s. In the coming decade growth of Chinese imports will be more muted for these products. Since the early 2000s, China's share of world soybean imports grew from less than 30% to more than 60% today; while its share of world imports of whole milk powder grew from less than 10% in the early 2000s to around 20%. Both import shares are expected to remain flat in the coming decade.

Figure 1.27. Ukraine and the Russian Federation: Share of global exports



Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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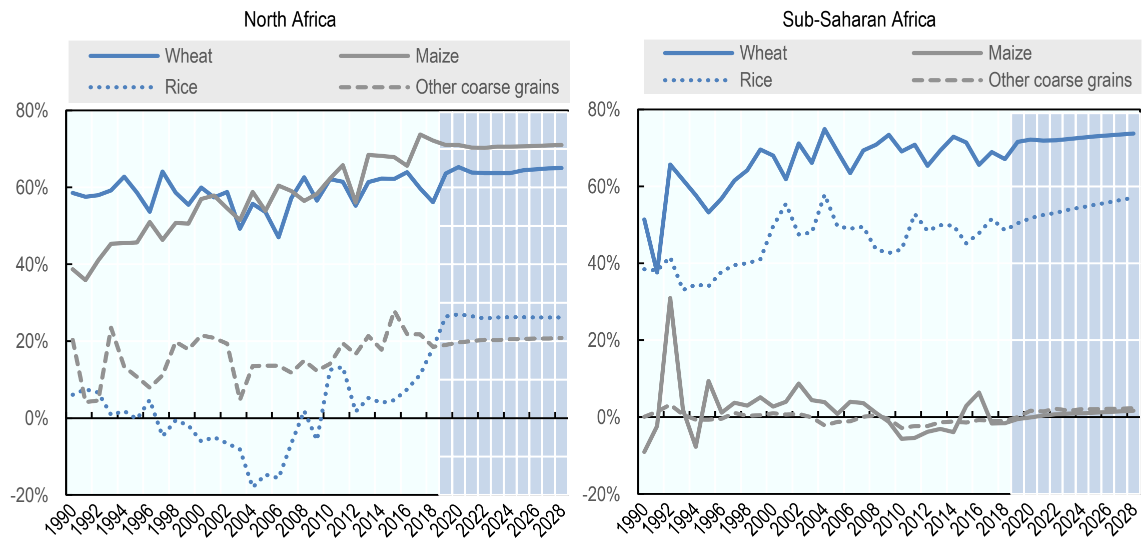
The growth of imports in Africa is linked to strong population growth and is expected to continue throughout the decade (although this *Outlook* does not cover tropical products, of which Africa is a net exporter). As Figure 1.28 indicates, both North and Sub-Saharan Africa are net importers of cereals, which support food security both directly and through use as animal feed. In North Africa, maize and other coarse grains are predominantly used as feed, while wheat and rice are used as food. The region is a net importer across these four categories, a situation which is expected to continue in the coming decade. Growing cereal imports in North Africa in turn support the growth of cereals exports in the Russian Federation and Ukraine, which benefit from their proximity to the region. In Sub-Saharan Africa, maize (especially white maize) and other coarse grains (including local grains such as teff) are mostly used as food, and the region is self-sufficient for these traditional cereals. As incomes grow, the demand for rice and wheat is increasing, leading to rising imports. The impact will be especially pronounced for rice, where Africa's share of world imports is expected to grow from 35% to 50% over the outlook period.

The agricultural trade balance of India is notable, as the country is currently neither a major importer nor a major exporter, despite its size. However, given the country's size, changes in its trade balance could have a big effect on markets. In the coming decade, domestic production is expected to keep up with growing population and higher incomes, with little change in its overall trade position. For instance, the strong growth in India's consumption and production of dairy are expected to have little effect on global markets. Notable exceptions are vegetable oil, for which India is a major importer, as well as rice and carabeef (buffalo meat), for which India is a leading exporter. The coming decade will further consolidate these positions.

Figure 1.28. Ratio of net imports to domestic utilisation



Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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Free trade agreements affect agricultural trade projections

On average, agriculture faces much higher trade barriers than manufacturing. While successive rounds of multilateral trade negotiations have succeeded in reducing import tariffs for manufacturing, progress in reducing agricultural protectionism has been more limited. The 1995 WTO Agreement on Agriculture was an important breakthrough, and led to increased market access and limits on trade-distorting support to producers. Despite this progress, agricultural products in recent years still face average import tariffs of around 16% compared to 4% for industrial goods.[19] Moreover, some agricultural commodities often face much higher tariffs in countries where these commodities are considered sensitive. Progress in multilateral negotiations has stalled, and hence most of these barriers to trade are expected to continue shaping trade flows throughout the next decade. However, countries have increasingly turned to bilateral and regional trade agreements, which can affect agricultural trade projections. Overall, the share of trade in total agricultural production is expected to remain constant throughout the next decade.

Since the last *Agricultural Outlook*, two large free trade agreements (FTAs) have been ratified: the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the EU-Japan Economic Partnership Agreement (EPA). Both agreements include, among other provisions, commitments to increase market access for agricultural products. (The trade agreement between Canada, the United States and Mexico to replace the North American Free Trade Agreement has not yet been ratified; this *Outlook* therefore assumes that NAFTA remains in effect).

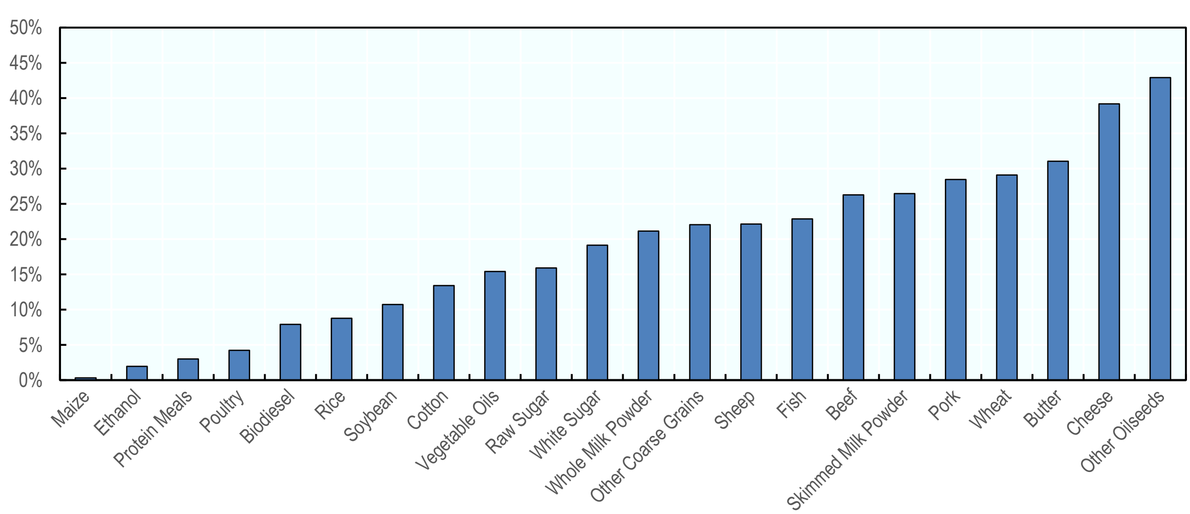
The CPTPP is a trade agreement between 11 countries: Australia, Brunei Darussalam, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, and Viet Nam. Under the agreement, most tariff lines will become duty-free.[20] In 2016, these countries accounted for around 20% of global agricultural exports and imports. For several commodities such as butter, cheese, and other oilseeds, intra-CPTPP trade already accounts for an important share of total trade of these countries (Figure 1.29).

While detailed projections of the trade-promoting effect of the agreement cannot be provided in this *Outlook*, the largest impacts are expected on trade in meat, dairy products and to a lesser extent cereals. Import tariffs for these products can be relatively high. For example, beef imported into Japan faces duties of 38.5%, which will be lowered to 9% under the CPTPP. Import tariffs on dairy products in Canada and poultry in Mexico can reach up to 250% and 234%, respectively. These tariffs will come down under the CPTPP. Overall, Japan's imports are likely to be particularly affected, as it is the largest net importer of most of these products in value terms.

The EU-Japan Economic Partnership Agreement (EPA) entered into force on 1 February 2019 and liberalises most tariff lines between the European Union and Japan. For the European Union, the agreement is expected to bring considerable gains in the agricultural sector.[21] The European Union is already an important supplier of agricultural products to Japan for butter, white sugar, pork, and cheese (trade flows in the other direction are more limited). The EPA seems likely to increase agricultural trade flows from the European Union to Japan, in particular for pork, beef, poultry and dairy products. While the *Agricultural Outlook* does not model bilateral trade flows, these likely effects have been taken into account in preparing the projections for EU exports and Japanese imports.

International trade in agricultural products is currently facing several risks and uncertainties related to the ongoing US-China trade conflict and uncertainty around the terms of the departure of the United Kingdom from the European Union, among others. These are discussed in more detail in the next section.

Figure 1.29. Intra-regional trade shares for CPTPP in 2016



Note: Data shows the share of total trade of CPTPP countries accounted for by trade with other CPTPP countries.
Source: Global Trade Tracker (2019).

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1.6. Risks and uncertainties

Sensitivity analysis

The projections in the *Agricultural Outlook* are based on a set of assumptions about the likely development of demographic and macro-economic variables (detailed in Box 1.4) as well as an assumption of average weather conditions. The Aglink-Cosimo model underlying the *Outlook* can be used for scenario analyses to explore how different assumptions affect the projections. For instance, a recent study using the Aglink-Cosimo model relaxed the assumption of average weather conditions and modelled the implications of extreme climate events for agricultural markets, as described in Box 1.3.

Box 1.3. Potential effects of extreme climate events

Extreme climate events such as heat waves, droughts, and heavy rainfall will likely occur more frequently and last longer in many areas.[1] Such events often have a strong effect on crop production. Projections in the *Agricultural Outlook* typically assume average agro-climatic conditions during the growing season. Crop yields generally follow their historical trends and therefore do not capture the potential effect of rare and high biophysical stress.

In a recent study researchers of the European Commission's Joint Research Centre have extended the Aglink-Cosimo model underlying this *Outlook* to take into account yield deviations attributable to temperature and water-based anomalies using information on historical extreme events.[2] By experimentally simulating the recurrence of 58 cases of regional extreme events affecting wheat, maize, and soybean, from the period 1980-2010 into the marketing year 2019/20, the potential economic impacts on key domestic and international commodity markets were examined.

Depending on the attributes (e.g. duration and intensity) of the extreme events analysed, impacts on domestic production were estimated to range from -28% (Australia) to +41% (Kazakhstan) for wheat, from -49% to +68% (South Africa) for maize, and from -12% to +13% (United States) for soybean. These deviations led to significant differences in domestic and international crop prices compared to a situation with average conditions. Overall, domestic prices could range from -10% (Kazakhstan) to +125% (Pakistan) for wheat, from -21% to +310% (South Africa) for maize, and from -24% to +58% (India) for soybean. The transmission of prices to global markets was found to be pronounced in the case of large shocks in key exporters and importers. For instance, international reference prices of wheat could range from –6% to +10% due to extremes exclusively in the Russian Federation, while prices of maize (–13% to +35%) and soybean (–14% to +15%) would be notably affected by extreme events in the United States. Similarly, significant trade impacts were found in both directions. Damaging events, for instance, would ultimately dictate lower export competitiveness, higher import dependency, lower self-sufficiency, and occasionally temporary price volatility.

Overall, crop prices are more sensitive to damaging events than to beneficial ones. This implies that trade and stocks may not always be enough to "buffer" the damage from simultaneous and recurrent harvest failures, which could render future prices even more responsive. Formulating policy responses, such as multi-country emergency reserves, to extreme agro-climatic events will however require a deeper understanding of two factors:

the likelihood and magnitude of simultaneous and recurrent events across the globe, and the degree to which different regions can adapt through resistant crop varieties, early warning systems, and efficient water use. In the absence of such information, it would be difficult for governments in food-insecure regions not only to specify and agree on optimal stock quantities to be held but also to sustain supply- or price-stabilising buffer stock schemes in practice.

1. IPCC (2012), "Managing the risks of extreme events and disasters to advance climate change adaptation," Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.
2. Chatzopoulos T., Pérez Domínguez I., Zampieri M., Toreti A. (2019), "Climate extremes and agricultural commodity markets: A global economic analysis of regionally simulated events", in Weather and Climate Extremes, https://doi.org/10.1016/j.wace.2019.100193.

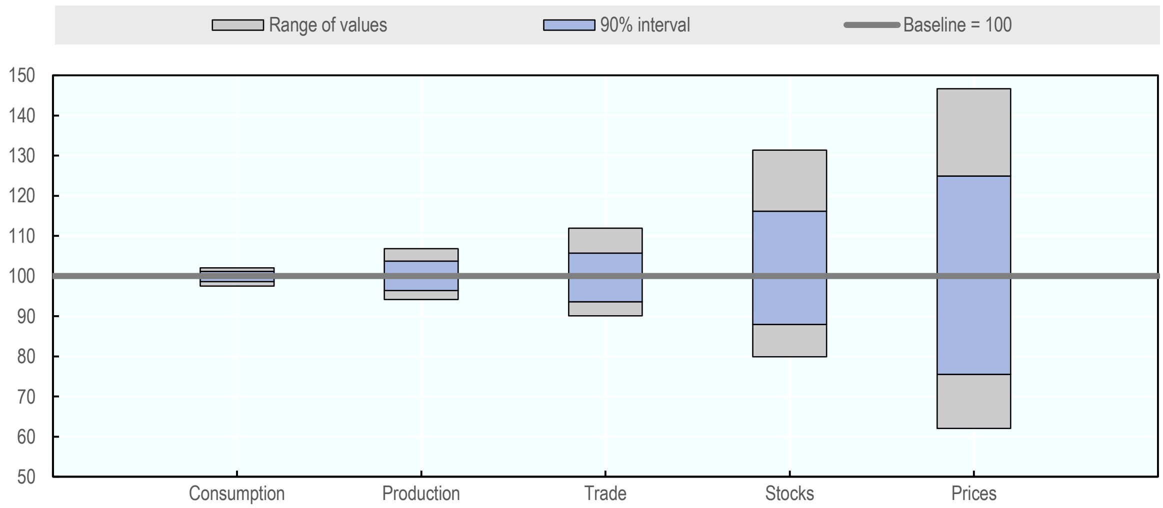
A partial stochastic analysis has been used to assess how "typical" variation in macro-economic variables affects the projections. In this analysis, 1 000 different simulations are run using random combinations of variations of variables such as the oil price, exchange rates, economic growth, and yield shocks. The variations are chosen according to the historical deviation of these variables from their long-run trend.

The analysis is partial, as not all sources of variability affecting agricultural markets can be captured. For example, animal diseases such as African Swine Fever can have important effects on markets but are not included here. Nevertheless, the results of these scenarios give an indication of the sensitivity of the projections to some of the most important sources of variability in agricultural markets.

A first finding of the stochastic analysis is that consumption projections tend to be less sensitive to shocks than production projections, which in turn are less sensitive than trade, stock levels or prices. This finding is illustrated in Figure 1.30 for maize, comparing the baseline projection for 2028 with the full range of values observed in the stochastic analysis as well as the 90% interval (i.e. the range which includes 90% of the simulated scenarios). Agricultural supply and demand tend to be relatively insensitive to price changes, which means that shocks can lead to large variation in prices. The stochastic analysis suggests these shocks could lead to prices up to 40% above or below those projected in the baseline.

The stochastic analysis also provides insight into the relative importance of different types of shocks. Figure 1.31 compares results for the maize price in 2028 using all shocks in the stochastic analysis or various subsets of shocks. Prices appear most sensitive to shocks in yields; in simulations where only yield shocks are included, the maize price in 2028 can end up 20% above or below the baseline projection. Exchange rates and oil prices are also an important source of variation. Interestingly, in both cases the simulations reveal an asymmetric response of prices. In the simulations, exchange rate shocks induce price increases of up to 10% but price decreases of up to 20%. Historical shocks to exchange rates (from which stochastics are drawn) have been asymmetrical in many countries, with large depreciations relative to the US dollar occurring more frequently than equally-large appreciations. As commodity prices are denoted in US dollars, such large depreciations tend to stimulate exports and discourage imports. Since agricultural exports are often concentrated among only a handful of countries, depreciations in major exporters can lead to important increases in global exports and hence relatively large declines in world prices. Shocks to oil prices, on the other hand, induce price increases of more than 10% but price decreases of up to 6% because historical shocks to oil prices have been asymmetrical, with large increases occurring more frequently than equally-large decreases. Finally, income shocks lead to prices which are up to 10% above or below the baseline projection, although most of the simulated outcomes are found in a more narrow range of a few percentage points around the baseline projection.

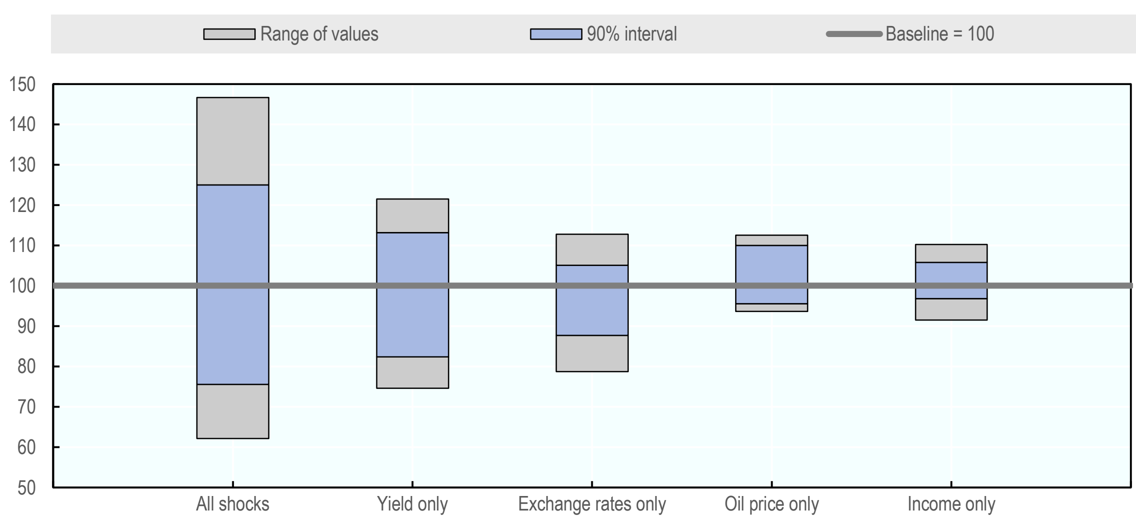
Figure 1.30. Range of outcomes for maize in 2028



Note: Chart shows the range of values obtained in the partial stochastic analysis, where the baseline value is normalised to 100.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957764

Figure 1.31. Range of outcomes for the world maize price in 2028, by type of shock



Note: Chart shows the range of values for the world maize price obtained in the partial stochastic analysis for different types of shocks. The baseline value is normalised to 100.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957783

The stochastic analysis thus sheds some light on the sensitivity of the projections to a range of shocks. However, various other uncertainties are harder to quantify. The potential impact of several of these uncertainties is discussed below.

Uncertainties to the projections

Demand

The *Agricultural Outlook* incorporates the likely evolution of consumption preferences. Alternative assumptions about their development, such as a wider spread of vegetarian, vegan or "flexitarian" lifestyles, would alter the medium term projection trend. Short run shocks, like food health scares, which are not considered in the projections, would lead to fluctuations around the food consumption projections in the *Outlook*.

The *Outlook* holds policies fixed in the medium term and makes assessments about their future effectiveness. These conventions also constitutes a source of uncertainty. For instance, policy measures introduced to reduce overall calorie consumption or to shift consumers towards healthier diets could affect both the overall demand for food as well as the relative demand for different food products in ways that are unforeseen today. Similarly, policies to stimulate more sustainable diets could affect consumption patterns differently than the expert consensus underling the *Outlook* has suggested.

The assessment of the effectiveness of biofuel polices remains uncertain as well. For instance, the Chinese government has announced a nationwide 10% ethanol blending mandate by 2020. The *Outlook* assumes that a blending rate of only about 4% can be reached by 2028. If China were to reach the 10% blending target, it would require large amounts of additional maize, cassava and/or sugarcane as feedstock, altering the outlook for crops and livestock products.

Supply

The projections in this *Outlook* are sensitive to outbreaks of plant and animal diseases, which are impossible to predict but may have significant and long-lasting effects. One example of such a pest outbreak is the Fall Armyworm, an insect native to the Americas which spread to Sub-Saharan Africa in 2016. This pest predominantly attacks maize, but can also damage numerous other crops including rice, cotton and sugarcane. FAO estimates that the damage of Fall Armyworm in Africa currently ranges between USD 1 and USD 3 billion. The *Outlook* assumes the infestation can be largely controlled and no widespread devastation over the medium term will occur. In July 2018, the insect was detected in India and Yemen; by January 2019 it had spread to Sri Lanka, Bangladesh, Myanmar, Thailand, and China's Yunnan province. While data for Asia are not yet available, the projections assume the impact to be less severe than in Africa because of a better availability of crop protection products.[22] No other disease outbreaks are incorporated in the *Outlook*, but such occurrences would either result in short-term shocks around the projected trends, or, in severe cases, alter them permanently.

Animal diseases have in the past disrupted poultry, beef and other livestock markets, and have the potential to do so again during the coming decade. A current epidemic affecting livestock production is the African Swine Fever, which is fatal to pigs and wild boars although it does not affect humans. In August 2018, China reported an outbreak of African Swine Fever, the first reported case in the country. In the meantime, the disease has also been detected in other countries in Asia, and has re-emerged in Europe (where cases had previously been detected in 2007 and 2014). The medium-term impact of the disease on global pork production is uncertain. Measures to contain the outbreak are assumed to moderately depress global pork production in the short term. As their success is uncertain, the medium term impact of the epidemic may become more severe than currently anticipated.

The projected yield trends and trends in animal productivity in the *Outlook* assume continued improvements to the genetic potential of crops and farm animal and ongoing innovations in the production technology, which in turn depend on continued public and private investments into research and development (R&D). A large literature has demonstrated the substantial social benefits from public investments in agricultural R&D, which suggests that current rates of investment are too low.[23] Yet, in high-income countries, public investments appear to have fallen since the financial crisis of 2008-9.[24] As these countries accounted for half of global public spending on agricultural R&D in 2008, this trend could lead to lower productivity growth in the coming decades On the other hand, public R&D spending is growing among emerging economies, notably in China and India.[25] Moreover, global private-sector R&D investments have been growing faster than public R&D spending in recent years.[26] These trends support the assumptions of continued productivity growth in this *Outlook*, but any alternative scenario with respect to the assumed rate of progress would alter the projections.

In the coming decade, agricultural production will be shaped by a wide array of policy measures that aim to guide production practices. They pursue various objectives, such as combating climate change, protecting animal welfare and human health, increasing domestic self-sufficiency or meeting export targets. The *Outlook* has incorporated expectations on the impact of all known measures, however, their actual outcomes are uncertain and they are subject to change.

International trade

The ongoing trade tension between the United States and China continues to create uncertainty around the projections in the *Outlook*. In the summer of 2018, Chinese tariffs on US soybean led to a decline in US exports. Estimates by the US Department of Agriculture suggest US soybean exports to China fell by 22 Mt year over year.[27] Increased exports to other destinations increased by around 7 Mt, leading to a net reduction of around 13.5 Mt. The Chinese tariff created a gap between the US and Brazilian soybean export price over the summer of 2018, which disappeared near the end of the year as China pledged additional purchases of US soybeans and other crops. At the time of writing, negotiations were ongoing between the United States and China. As no specific end date was set for the Chinese tariffs, the *Outlook* assumes these remain in place throughout the projection period, in line with the *Outlook's* overall approach, which holds policy settings constant. Any negotiated resolution to this dispute is likely to impact Chinese imports and US exports of soybeans as well as global soybean prices and market shares of other countries, given the importance of China and the United States in the global soybean market.

On 29 March 2017, the UK government officially announced its intention to leave the European Union, a process commonly referred to as Brexit. During the preparation of the *Agricultural Outlook*, the terms of departure were still unclear. Hence, the *Outlook* assumes no disruption to trading relations between the United Kingdom and the European Union. The impact of Brexit could be substantial, as the United Kingdom has a strong trading relationship with the European Union. In 2018, more than 70% of the country's agricultural imports came from the European Union and 62% of the country's agricultural exports went to the European Union. Overall, the country is a net importer of agricultural products, and in 2018 it had an annual agri-food trade deficit of USD 27 billion with the rest of the European Union. While trade between EU Member States is tariff free, Brexit could result in higher trade barriers, which would affect agricultural prices and production in the UK and the European Union. In addition, the UK farming sector receives on average 60% of farm incomes from the EU Common Agricultural Policy (CAP) subsidies. Even though the government is committed to maintaining these subsidies until 2020, the subsequent withdrawal of support could affect domestic production and prices. Brexit may have a global impact on markets for cheese, butter, pork and sheep meat, commodities for which the United Kingdom is a large net importer. For instance, the United Kingdom is the world's largest net importer of cheese. For other markets, the main effect may be a reallocation of trade flows to other trade partners with less impact on overall numbers.

The USMCA is the preferential trade agreement between the United States, Mexico and Canada, which is set to replace the NAFTA. It was signed on 30 November 2018, but has not yet been ratified. Therefore, it has not been incorporated in the baseline projections. Compared to NAFTA, there are only modest market access increases in agriculture under the USCMA. Agricultural products that could be imported at a zero tariff rate under NAFTA will remain at zero tariffs under the USMCA. When compared to NAFTA, the USMCA maintains existing agriculture commitments between United States, Mexico and Canada, with relatively free market access across the countries. The major improvements will be the increased market access for Unites States dairy, poultry and eggs exports to Canada. The Canadian government secured new market access in the United States for certain dairy products and in the form of tariff rate quotas for refined sugar and sugar-containing products. For Mexico, the USMCA would not lead to any significant changes in market access in agriculture.

Data

The *Agricultural Outlook* is built on a comprehensive dataset of global agricultural production, consumption, trade, and prices, and incorporates data from national statistical sources, international organisations (notably FAO), international commodity bodies (such as the International Grains Council), and private data providers. While global and regional aggregates and data for developed countries are generally reliable, in some cases historical data are estimates with potential measurement error. The historical data are regularly updated when revisions become available, which normally has little impact for the global picture.

However, recent data revisions in China pose a particular uncertainty. Following China's 2017 census, its National Bureau of Statistics released revised estimates of agricultural production going back to 2007 and for fisheries and aquaculture back to 2009. These revisions imply that Chinese cereals production has been significantly higher over the past decade than previously assumed. For maize, the cumulative revision amounts to 266 Mt, or an increase of around 10%. Upward revisions were also published for other cereals. For dairy, by contrast, new estimates imply production is up to 15% lower than previously assumed.

The higher estimates of maize production raise the question where this additional production has ended up. It is not clear whether the additional maize has ended up as feed (which would either imply greater livestock production or more intensive use of feed than previously believed). On the other hand, assuming the additional production has ended up in stocks poses other issues, as it is not clear who would be holding these stocks and where they would be located.[28]

The revisions to Chinese statistics not only impact historical numbers, but also raise questions about the transparency of global agricultural markets. Having reliable stock data is essential to assess the resilience of global agricultural markets to shocks. The revision of Chinese production numbers thus points to a broader issue of uncertainty around stock estimates. These stocks (for China and for other countries) are often not known directly, but annual changes are estimated based on the difference between production and consumption, which makes stock estimates particularly vulnerable to measurement errors. Given the importance of reliable data on global food availability, more work is needed to improve global stock estimates, for instance through direct surveys.[29]

Box 1.4. Macroeconomic and policy assumptions

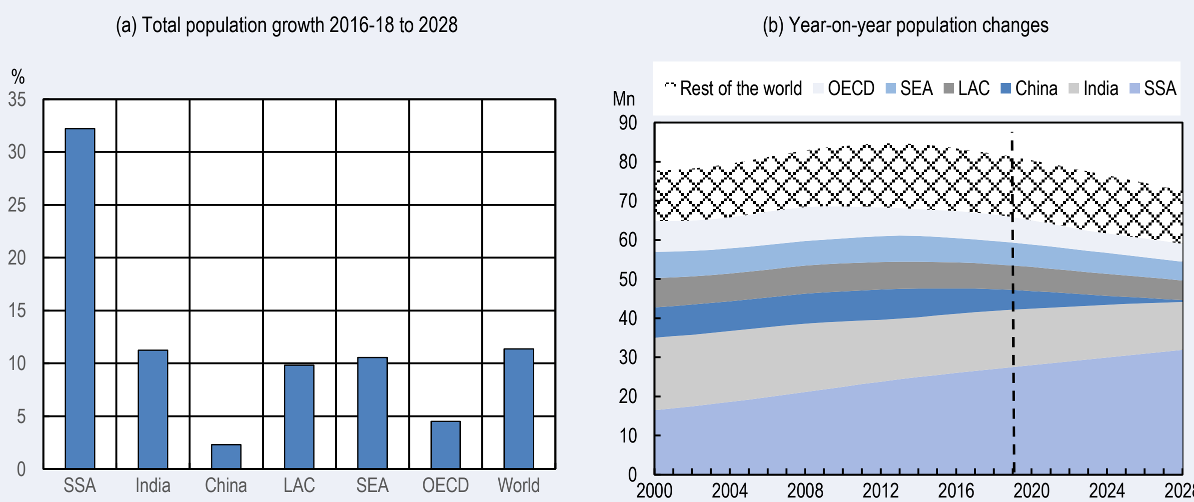
The main assumptions underlying the baseline projection

This *Outlook* presents a scenario that is considered plausible given assumptions on the macro-economic, policy and demographic environment, which underpins the projections for the evolution of demand and supply for agricultural and fish products. Detailed data are available in the Statistical Annex; the main assumptions are highlighted in this box.

Population growth

The *Agricultural Outlook* uses the UN Medium Variant set of estimates from the 2017 Revision of the United Nations Population Prospects database.

Figure 1.32. World population growth



Note: SSA is Sub-Saharan Africa; LAC is Latin America and Caribbean; SEA is Southeast Asia.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink http://dx.doi.org/10.1787/888933957802

Over the projection period, world population is projected to grow from 7.5 billion people in 2016-18 to 8.4 billion people in 2028. This represents an annual growth rate of 1%, a slowdown compared to the 1.2% p.a. growth rate in the last decade. This growth is concentrated in developing regions, particularly Sub-Saharan Africa, which is expected to have the fastest growth rate at 2.4% p.a., and India, where the population is projected to grow by 0.9% p.a. With an additional 136 million people by 2028, India is expected to overtake China as the most populous country.

Per capita income growth

Estimates of per capita income growth are taken from the *OECD Economic Outlook* No. 104 (November 2018) and the *IMF World Economic Outlook* (October 2018). They are expressed in purchasing-power parity terms, in constant 2011 US dollars.

The demand for food depends on households' disposable incomes, which are approximated in this *Outlook* using the growth in per capita GDP. However, the effects of economic growth can be unevenly spread, which influences average consumption. In particular, the incomes of the poorest 40% have lagged average income growth in several Sub-Saharan African countries, as highlighted in the World Bank's Poverty and Shared Prosperity 2018 report. For this reason, demand projections in this *Outlook* sometimes deviate from what might be expected based on average growth.

Over the projection period, global income per capita is expected to grow by 2.5% p.a. in real terms. In India, strong economic growth is expected to double per capita incomes over the projection period (6.6% p.a.). Economic growth in China is expected to slow down in the coming decade, although per capita incomes are still expected to grow by 63% (4.1% p.a.) over the projection period. Other developing countries in Asia are projected to continue experiencing robust growth over the medium term. The growth of per capita incomes in Viet Nam, Indonesia, and the Philippines is anticipated to be in the 4-6% p.a. range, while that in Thailand is at around 3.3% p.a. In Pakistan, growth will be slower at 1.2% p.a. In Sub-Saharan Africa, per capita incomes are expected to grow by 14.2% over the projection period, in particular due to high economic growth expected in Ethiopia at 7.6% p.a. over the next ten years. In countries of the Latin America and Caribbean region, per capita growth varies considerably by country. While incomes in Brazil and Mexico will grow relatively slowly in the next decade (at around 2% p.a.), countries such as Peru, Paraguay and Colombia will see per capita incomes grow by 2.8% p.a.

In OECD countries, per capita income is expected to grow around 1.9% p.a. in the coming decade. Higher growth is expected for Turkey at 3.1% p.a. while per capita incomes are expected to grow slowest in Canada at 1.3% p.a.

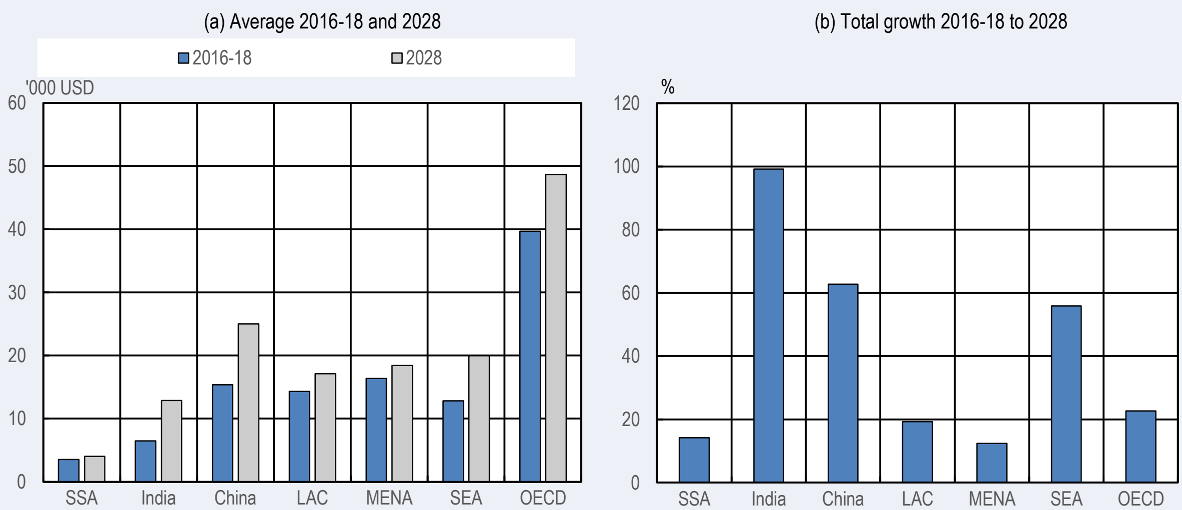
Global growth

GDP growth assumptions are based on the *OECD Economic Outlook* No. 104 (November 2018) and on the *IMF World Economic Outlook* (October 2018).

The global economy is expected to grow at a rate of 3.4% on average over the next ten years. Figure 1.34 shows growth rates of GDP for major regions and for selected countries of Latin America, the subject of this year's focus chapter. Globally, the highest growth will be registered in India (at 7.7% p.a.). In Latin America, the fastest total GDP growth will be seen by Paraguay at 4.0% p.a.

Figure 1.34 also decomposes the GDP growth assumptions into per capita GDP growth and population growth. Globally, economic growth will mostly correspond to per capita income growth; this is especially the case in OECD countries and in China. By contrast, high population growth in Sub-Saharan Africa means that the relatively high rate of economic growth in the region (at close to 4% p.a.) corresponds to only modest growth in per capita incomes (around 1.3% p.a.).

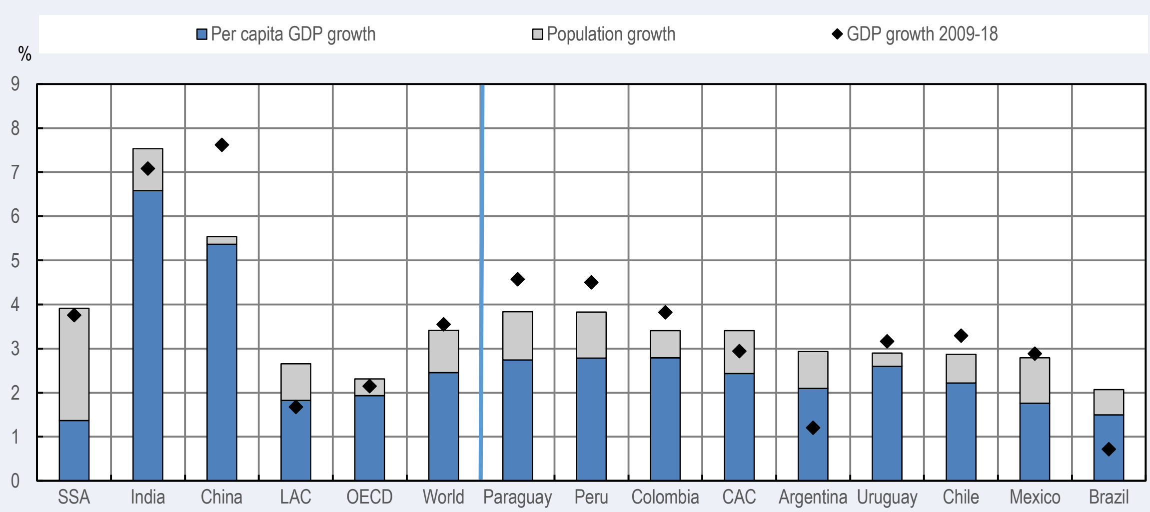
Figure 1.33. Per capita income growth



Note: SSA is Sub-Saharan Africa; LAC is Latin America and Caribbean; MENA is Middle East and North Africa; SEA is Southeast Asia. Panel (a) shows per capita GDP in purchasing-power parity (PPP) terms (constant 2011 US dollars).
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database).

StatLink http://dx.doi.org/10.1787/888933957821

Figure 1.34. Annual GDP growth rates 2019-2028



Note: SSA is Sub-Saharan Africa; LAC is Latin America and Caribbean; CAC is Central America and Caribbean.
Source: OECD/FAO (2019), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database).

StatLink http://dx.doi.org/10.1787/888933957840

Exchange rates and inflation

Exchange rate assumptions are based on the *OECD Economic Outlook* No. 104 (November 2018) and on the *IMF World Economic Outlook* (October 2018). Real exchange rates for the period 2019-28 are assumed to be broadly stable, so that nominal exchange rates relative to the US dollar are mostly driven by differences in inflation compared to the United States. Some currencies are expected to appreciate in real terms compared to the US dollar; this is the case for Mexico, Paraguay and Uruguay. By contrast, a real depreciation is expected for Argentina, Brazil and Australia.

Inflation projections are based on the private consumption expenditure (PCE) deflator from the *OECD Economic Outlook* No. 104 (November 2018) and on the *IMF World Economic Outlook* (October 2018). Inflation is projected to increase over the next few years in both advanced and developing economies, reflecting the recovery in demand and the increase in real commodity prices. In the United States, inflation of 2.1% p.a.is expected over the next ten years, and in the Euro zone at 1.7% p.a. In other OECD countries, inflation is expected to average 3.5% p.a. Among the major emerging economies, consumer price inflation is projected to remain stable in China at around 2.9% p.a., and to ease slowly in Brazil at 4.6% p.a. Similarly, consumer price inflation in India should decrease from an annual growth rate of 6.8% to 4.1% p.a. over the next ten years.

Even though US inflation is slightly higher than inflation in the Euro zone, the Euro is expected to depreciate relative to the US dollar in both nominal and real terms. The currencies of China, Canada, Korea, New Zealand, Australia, the Russian Federation and Japan are expected to depreciate nominally. Relatively strong depreciations are projected for Argentina, Brazil, Turkey, Uruguay and India.

Input costs

The projections in the *Agricultural Outlook* are based on assumptions about agricultural production costs, which include costs of seed, energy, fertilisers, and various tradable and non-tradable inputs. The projections are guided by the evolution of a composite cost index based on these input costs and constructed using historical cost shares for each country and commodity (held constant for the duration of the outlook period). Energy costs are represented by the international crude oil price expressed in domestic currency. The evolution of costs of tradable inputs such as machinery and chemicals is approximated by the development of the real exchange rate, while the evolution of costs of non-tradable inputs (mainly labour costs) are approximated by the evolution of the GDP deflator. The evolution of seed and fertiliser prices is approximated in an iterative way, as these input costs depend in part on crop prices (and, in the case of fertiliser, on crude oil prices).

Historical data for world oil prices to 2017 are based on Brent crude oil prices obtained from the short-term update of the *OECD Economic Outlook* N°104 (November 2018). For 2018, the annual average monthly spot price in 2018 was used, while the estimate for 2019 is based on the average of daily spot prices in December 2018. For the remainder of the projection period, oil prices are assumed to remain flat in real terms, which implies an increase in nominal terms from USD 58/barrel at the end of 2018 to USD 70/barrel in 2028.

Policy considerations

Policies play an important role in agricultural, biofuel and fisheries markets, with policy reforms often changing the structure of markets. This *Outlook* assumes that policies will remain as they are throughout the projection period. The decision by the United Kingdom to exit the European Union is not reflected in the projections as the terms of that departure were not determined as this *Outlook* was being prepared. Nevertheless, the United Kingdom is reported separately from the rest of the European Union in this report.

In the case of bilateral trade agreements, only ratified or implemented agreements are incorporated. The Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), which was signed in March 2018 and implemented, following ratification in most member countries, at the end of 2018, is included (see the Trade section of the Overview chapter for a discussion of its effects). As of February 2019, the Japan-European Union Economic Partnership Agreement entered into force. Also, the partly implemented but not yet ratified Comprehensive Economic and Trade Agreement (CETA) between Canada and the European Union is incorporated. On the other hand, the North American Free Trade Agreement (NAFTA) remains unchanged throughout the *Outlook* projection period as the new trade agreement to replace NAFTA, the United States—Canada—Mexico Agreement (USMCA) has not yet been ratified.

The ban by the Russian Federation on imports originating from specific countries was announced as a temporary measure and this *Outlook* assumes that the ban will be revoked at the end of 2019. The temporarily increased tariffs by the United States and China are maintained throughout the *Outlook* period as no formal end date is announced. The specific assumptions on biofuel policies are elaborated in the biofuel chapter.

Notes

[1] For short-term market monitoring and outlook, see in particular the Agricultural Market Information System (www.amis-outlook.org) and FAO's Global Information and Early Warning System (www.fao.org/giews/en/). For long-term projections to 2050, see e.g. FAO (2018) The Future of Food and Agriculture – Alternative pathways to 2050; Adenäuer, Brooks and Saunders (2019), "Analysis of Long-term Challenges for Agricultural Markets" *OECD Food, Agriculture and Fisheries Papers*, forthcoming; as well as other approaches reviewed by Hertel et al. (2016) "Predicting Long-Term Food Demand, Cropland Use, and Prices," Annual Review of Resource Economics 8, 417-441.

[2] See http://www.agri-outlook.org/about/

[3] See Reardon and Timmer (2012), "The Economics of the Food System Revolution," *Annual Review of Resource Economics* Vol. 4, pp. 225-264.

[4] For a decomposition of production growth in the developing world into area and yield expansion, and an examination of the different factors contributing to higher yields, see e.g. Evenson, R. and D. Gollin (2003) "Assessing the Impact of the Green Revolution, 1960 to 2000," *Science 300*(5620), pp. 758-762.

[5] See Phelps and Kaplan (2017) "Land use for animal production in global change studies : defining and characterizing a framework," *Global Change Biology*, 23(11), pp. 4457-4471. The *Agricultural Outlook* uses the FAOSTAT definition of pasture.

[6] The relative contribution of yield growth and area expansion is important for understanding the likely expansion of agricultural land and the resulting pressures on the natural environment.

However, higher yields are not always economically optimal, for instance when the economic cost of additional inputs would be higher than the value of additional output. In addition, increasing yields may itself result in environmental damage, for instance when higher fertiliser use leads to nitrogen pollution in waterways. While yields are an important indicator, a focus on yields thus only gives a partial picture of productivity growth and environmental impacts in crop production. See e.g. Beddow et al. (2015) « Rethinking Yield Gaps », University of Minnesota College of Food, Agricultural and Natural Resource Sciences – Staff Paper P15-04.

[7] See e.g. the data available in the Global Yield Gap Atlas (www.yieldgap.org) and the analysis in Fischer, Byerlee and Edmeades (2014) "Crop yields and global food security: Will yield increase continue to feed the world?", Australian Centre for International Agricultural Research and Grains Research & Development Corporation.

[8] Data for 2016 from the World Bank's World Development Indicators (AG.CON.FERT.ZS), http://wdi.worldbank.org.

[9] See, for example, Christiaensen (2017) "Agriculture in Africa – Telling myths from facts: A synthesis," *Food Policy* 67, 1-11; Haggblade et al. (2017) "The Herbicide Revolution in Developing Countries: Patterns, Causes, and Implications," *European Journal of Development Research* 29(3), 533-559; and International Fertilizer Association (2018) *Fertilizer Outlook 2018-2022*.

[10] A comparison of experiences in the first two decades of the Green Revolution (1961-1980) and in later years (1981-2000) shows that the contribution of improved varieties has increased both in relative and in absolute terms. As the use of other inputs spreads, further yield growth is likely to increasingly depend on improved varieties. See Evenson and Gollin (2003), "Assessing the impact of the Green Revolution, 1960-2000," Science 300(5620), 758-762.

[11] On agricultural policies in the BRIC economies, see e.g. Brink et al. (2017) "BRIC Agricultural policies through a WTO lens," in: A. Bouët and D. Laborde, *Agriculture, Development, and the Global Trading System: 2000-2015*, IFPRI, and OECD (2018) *Agricultural Policy Monitoring and Evaluation 2018*.

[12] On the Russian Federation, see United States Department of Agriculture – Foreign Agricultural Service (2018) "Russian Federation – Agricultural Economy and Policy Report," GAIN Report RS1819, https://gain.fas.usda.gov; for Southeast Asia, see OECD (2017), *Building Food Security and Managing Risk in Southeast Asia*, OECD Publishing, Paris (pp. 107-8).

[13] See Smith et al. (2015) "Agriculture, Forestry and Other Land Use," in IPCC's Fifth Assessment Report, https://www.ipcc.ch/report/ar5/wg3/.

[14] Figures for 2016 from FAOSTAT, http://www.fao.org/faostat/en/.

[15] See, for example, Herrero et al. (2013) "Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems", Proceedings of the National Academy of Sciences, December 2013, 110 (52), pp. 20888-20893.

[16] See, for example, Blandford and Hassapoyannes (2018) "The role of agriculture in global GHG mitigation," *OECD Food, Agriculture and Fisheries Papers* 112, OECD Publications, Paris; World Resources Institute (2018) *Creating a Sustainable Food Future*, https://www.wri.org/publication/creating-sustainable-food-future; Smith et al. (2015) "Agriculture, Forestry and Other Land Use," in IPCC's Fifth Assessment Report, https://www.ipcc.ch/report/ar5/wg3/.

[17] See OECD (2019), "Options for Climate Change Mitigation in the Agricultural Sector : A Partial Equilibrium Analysis," forthcoming.

[18] See OECD (2019) "The changing landscape of agricultural markets and trade", *OECD Food, Agriculture & Fisheries Papers* 118, OECD Publications, Paris.

[19] See Bouët and Laborde (2017), "Assessing the potential cost of a failed Doha Round", in: A. Bouët and D. Laborde, *Agriculture, Development and the Global Trading System: 2000-2015*, IFPRI, Washington D.C.

[20] The CPTPP entered into force between Australia, Canada, Japan, Mexico, New Zealand, and Singapore on 30 December 2018. It entered into force for Viet Nam on 14 January 2019. The CPTPP will enter into force in the four remaining countries (Brunei Darussalam, Chile, Malaysia, and Peru) 60 days after they complete their respective ratification processes. Most tariff lines (around 86%) will become duty-free when the CPTPP enters into force for each CPTPP country. Some tariffs will be eliminated gradually over "phase-out" periods, which vary by country and tariff line, while a small number of tariff lines will not become duty free. Overall, around 99% of the CPTPP countries' tariff lines will be duty free within 15 years.

[21] Under the agreement, the European Union has agreed to liberalise 99% of its tariff lines and 100% of its imports while Japan liberalises 97% of its tariff lines and 99% of its imports. Once the trade agreement is fully implemented, Japan will have liberalised approximately 84% of all agricultural tariff lines while the European Union will have liberalised almost all agricultural products, with the exception of rice (which is mutually excluded) and some processed agricultural products.

[22] FAO is working with governments in both regions to inform and train farmers on how to combat the infestation. See http://www.fao.org/asiapacific/news/detail-events/en/c/1186008/

[23] See, for example, Alston et al. (2000) "A meta-analysis of rates of return to agricultural R&D: Ex pede Herculem?", IFPRI Research Report; Hurley et al. (2014) "Re-examining the reported rates of return to food and agricultural research and development," American Journal of Agricultural Economics 96(5), 1492-1504; Nin-Pratt and Magalhaes (2018) "Revisiting rates of return to agricultural R&D investment," IFPRI Discussion Paper 01718.

[24] See Heisey and Fuglie (2018) *Agricultural Research Investment and Policy Reform in High-Income Countries*, United States Department of Agriculture – Economic Research Service, May 2018.

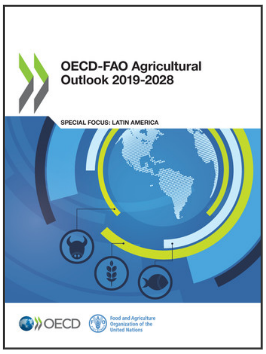
[25] See ASTI (2012) *ASTI Global Assessment of Agricultural R&D Spending*, Agricultural Science and Technology Indicators, https://www.asti.cgiar.org/globaloverview.

[26] See Fuglie et al. (2012) "The contribution of private industry to agricultural innovation," *Science* 338(6110), 1031-1032.

[27] R. Johannson (2019), "The Outlook for US Agriculture", speech delivered at the US Department of Agriculture's Agricultural Outlook Forum (21-22 February 2019).

[28] Ongoing work by the AMIS Secretariat is using estimates on the biological requirements of livestock to assess how much of the additional cereal production is likely to have ended up as animal feed. See *AMIS Market Monitor* No. 65 (February 2019), available at www.amis-outlook.org.

[29] For more information, see *AMIS Market Monitor* No. 64 (December 2018), available at www.amis-outlook.org.



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