1 The triple challenge

This chapter describes the main expectations of food systems in terms of the “triple challenge” of providing food security and nutrition for a growing population; providing livelihoods for hundreds of millions of people involved in farming and along the food chain, and contributing to environmental sustainability. The achievements of food systems are not as black and white as is sometimes assumed, as there has been remarkable progress in some areas. At the same time, major shortcomings exist on all three dimensions. Much is already known about how better policies could contribute to improving outcomes. Agricultural policies around the world tend to use highly distorting measures, often creating incentives for overproduction and overuse of inputs. Such policies are inefficient ways to improve livelihoods or food security, and often have negative environmental effects. Reforming these policies would go a long way to meeting the triple challenge.

Key messages

- Food systems around the world face a triple challenge of providing food security and nutrition to a growing global population, providing livelihoods to those along the food supply chain, and contributing to environmental sustainability.
- Globally, about 2 billion people do not have regular access to sufficient, safe, and nutritious food; an even greater number are overweight or obese.
- At the same time, technical and structural change and the repercussions of COVID-19 are putting pressure on the livelihoods of people working on 570 million farms worldwide and along other stages of the food supply chain.
- The environmental damage from food production is also considerable. Around 80% of all threatened terrestrial bird and mammal species are in danger because of habitat loss due to agricultural expansion; food production (including pre-production and post-production activities) accounts for 21-37% of anthropogenic greenhouse gas emissions.
- Much is already known about how better policies could contribute to improving outcomes. Agricultural policies around the world tend to use highly distorting measures, often creating incentives for overproduction and overuse of inputs. Such policies are inefficient ways to improve livelihoods or food security, and often have negative environmental effects.
- A food systems approach to policy making is needed to exploit synergies and manage trade-offs between the different dimensions of the triple challenge.

1.1. Introduction

Food systems around the world are expected to deliver on a formidable "triple challenge". The first requirement is to ensure food security and nutrition for all. The second is to provide livelihoods to farmers and others in the food chain, and promote rural development. The third is to do all this while ensuring environmental sustainability – i.e. using natural resources sustainably (including protecting valuable ecosystems and biodiversity) and reducing greenhouse gas emissions, as well as meeting other societal expectations such as animal welfare.[1]

The fact that these goals are a long way from being attained has led to charges of "systems failure". Yet the scale of past achievements is as remarkable as what remains to be done:

- The world population has grown from 3 billion in 1960 to about 7.5 billion today, and there is more food available per capita than ever before.[2] Yet globally about 2 billion people do not have regular access to sufficient, safe and nutritious food, while an even greater number are overweight or obese. [3] These and other forms of malnutrition are associated with a rising public health burden.
- The process of technical and structural change has benefited many farmers who have been successfully absorbed in faster growing parts of the economy, while consumers have benefited from lower food prices. However, it has put pressure on the incomes of farmers who are not able to compete, and in some countries led to distress migration to urban areas.
- The tripling of agricultural production since 1960 was achieved primarily through improved yields and productivity growth, with only modest overall change in agricultural area. Had those productivity gains not been realised, the consequences for human development and for the environment would have been devastating. Nevertheless, production growth has imposed stresses on soils and water resources. The agricultural sector also directly accounts for 12% of GHG

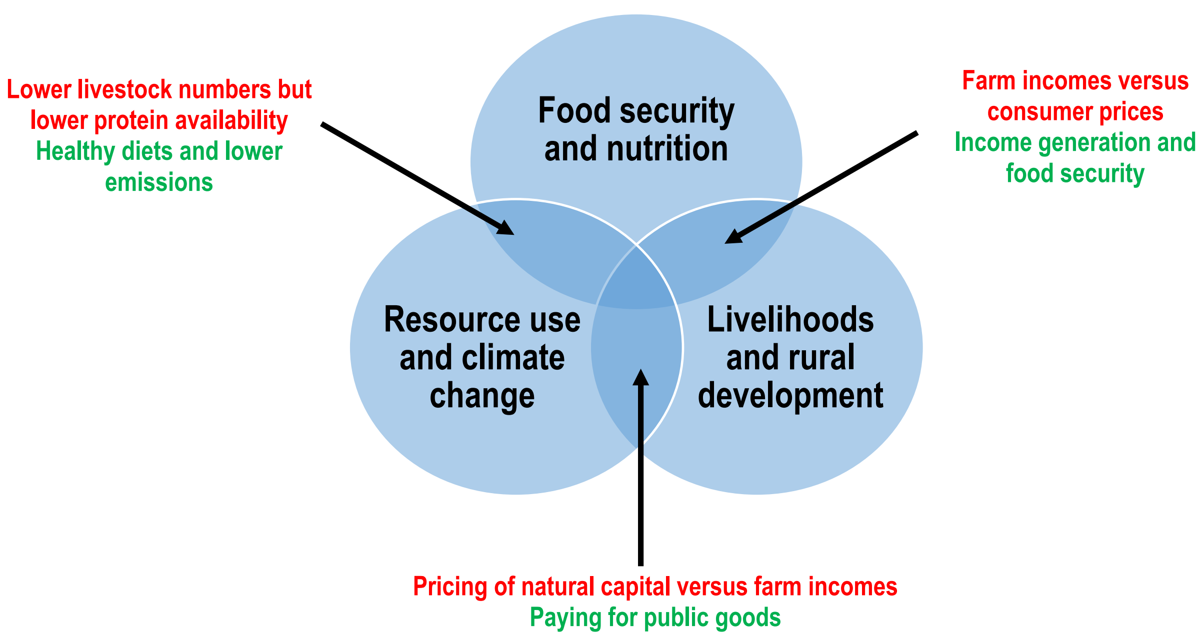
emissions, with that share more than doubling once land use change and the contribution of other segments of the food supply chain are factored in.[4]

The sudden outbreak of the COVID-19 pandemic in early 2020 created additional stresses on food systems, requiring interventions by policy makers to guarantee the continued functioning of supply chains and to ensure access to food for vulnerable consumers.[5] However, the triple challenge facing food systems around the world predates COVID-19, and will remain even as the disruption caused by this pandemic abates.

COVID-19 demonstrates the centrality and complexity of food systems, a term which covers "all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes" (HLPE, 2017[1]). There is diversity in how these processes operate in different parts of the world: some are global, while others are highly localised. Food systems globally consist of a multitude of national and local food systems which shape and are in turn shaped by global processes, in the same way that the global economy consists of interactions between national and local economies.[6]

Policy makers need to be able to navigate that complexity so that their decision-making processes are no more cumbersome than necessary, yet reflect an understanding of how actions in one area may affect outcomes in another. The triple challenge provides a simplified organising framework for considering the most salient interactions (Figure 1.1).

Figure 1.1. Examples of synergies and trade-offs in food systems



Note: Examples of synergies are noted in green; examples of trade-offs in red.

As this framework suggests, some objectives can be pursued more or less independently (the non-intersecting parts of the diagram), but there may be important synergies and trade-offs between different dimensions of the triple challenge (the intersecting elements). For example, dietary guidelines in several countries suggest people should adopt diets with a limit on the consumption of red meat. Insofar as these guidelines reduce demand for ruminant meat, there could be a benefit in terms of lower emissions (a synergy). Conversely, policies that lead to lower livestock production could reduce protein availability in regions where intake remains low (a trade-off) and could negatively affect livelihoods (a trade-off). Similarly, policies to raise farm productivity could generate income growth in agriculture and beyond, and benefit consumers through lower prices, but this will involve trade-offs with regard to producers who are not able to raise their productivity. As another example, paying for public goods could benefit the environment and simultaneously support farm incomes, but pricing natural capital according to its social cost could lower incomes, at least in the short term. Policies in one dimension can thus have spill-over effects on another dimension, and in some cases there are complex synergies or trade-offs across all three dimensions (the kernel of Figure 1.1).

This chapter provides a summary assessment of the performance of food systems across these three dimensions of the triple challenge. As the chapter shows, the frequent claim that food systems are “broken” overlooks important achievements across all three dimensions, although important challenges exist and require urgent attention. A key contention is that much is already known about how better policies can improve outcomes in each of the three dimensions. However, the discussion also shows there are wide gaps between policies that would be effective in addressing the triple challenge and the policies currently adopted in many countries. These gaps may arise due to difficulties in identifying and addressing synergies and trade-offs, but they may also reflect disagreements over facts, diverging interests, or differences over values.

Synergies and trade-offs between the three dimensions could have important implications for the choice of policy instruments and for the calibration of how much intervention is needed. For example, a policy to promote healthier diets by changing the level and composition of food demand could contribute to lower emissions but is unlikely to reduce emissions as much as required, meaning that other measures will also be required to address the latter objective. Similarly, a policy to raise agricultural productivity could reduce resource stress, implying less need for agri-environmental measures, but it could lower food prices and so increase the need for policies to curb overconsumption of some products. When there are trade-offs across the triple challenge there is no unique mix of policies that will provide the ideal outcome for every objective. Choices have to be made, and priorities established, in a way that attracts broad support across society. Responsibilities over different relevant policy areas may also be fragmented across different jurisdictions, and across different government agencies and levels of government within a country.

All this raises the question of how policy-making processes should be designed to achieve policies which are not only coherent, but sufficiently ambitious to meet the triple challenge. Chapter 2 discusses how policy makers can design coherent policies when confronted with synergies and trade-offs, while Chapter 3 analyses frictions related to facts, interests, and values, and how these can be managed to achieve better policies. In-depth case studies apply this analytical framework to the seed, ruminant livestock, and processed food sectors. These sectors represent different stages of the food chain, and the most salient policy issues differ by sector. Yet in each case there are clear linkages to the triple challenge, as well as synergies and trade-offs.

This report builds on a wide range of earlier OECD work (including analysis of global food security, diets and nutrition, income generation and poverty reduction, resource use and climate change) and extends this work by drawing out the importance of synergies and trade-offs across these domains. It also incorporates findings from several other studies on the policy challenges facing food systems, and complements other initiatives to address these challenges, such as the Collaborative Framework for Food Systems Transformation (UNEP, 2019[2]) developed as part of the multi-stakeholder One Planet Network Sustainable Food Systems Programme.

The remainder of this chapter is organised as follows:

- Section 1.2 considers the performance of food systems in delivering *food security and nutrition* and assesses outstanding policy priorities.
- Section 1.3 examines how food systems have contributed to *livelihoods along the food chain*, and the evidence on policies needed to generate incomes and improve livelihoods.

- Section 1.4 focuses on how the development of food systems has affected *resource use and emissions,* and the policies required to improve environmental sustainability and reduce emissions.
- A concluding section summarises the insights of this chapter and draws implications for the design of coherent policies and potential obstacles to achieving better policies, previewing the arguments in Chapters 2 and 3.

1.2. Challenge 1: Food security and nutrition

Food security is a multi-dimensional concept. According to the definition adopted at the 1996 World Food Summit (FAO, 1996[3]), food security exists when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." As this definition makes clear, food security is not only a matter of food availability – people will only be food secure when they have access to it, and when it leads to good nutritional outcomes. A fourth requirement is stability of these dimensions over time. This section takes stock of the performance of food systems with respect to the four criteria and identifies the principal policy requirements.[7]

Food availability

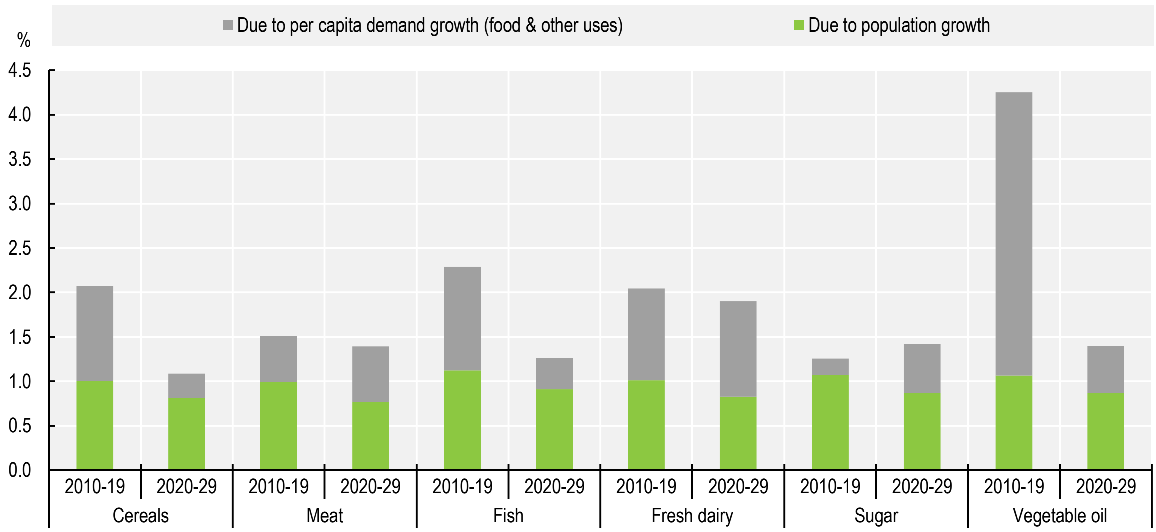
Despite occasional Malthusian fears, the overall availability of food has not historically posed a problem for global food security. Since 1960, world population has more than doubled, but food production per person has increased by more than 45%. There are few reasons to expect this trend to be reversed over the coming decades, although the longer term outlook is more uncertain if the extreme effects of climate change cannot be prevented (Brooks and Blandford, 2019[4]). The more pressing question is how food availability can be increased in an environmentally sustainable way.

Performance and outlook

The evolution of global food availability depends on the relative growth of demand and supply. The *OECD-FAO Agricultural Outlook* (OECD/FAO, 2020[5]) projects a marked slowing in the pace of demand growth over the coming decade, with global demand for cereals, meat and fish growing broadly in line with global population (Figure 1.2).

In most countries, per capita demand for cereals has reached consumption levels that are close to saturation. There is some scope for higher per capita meat consumption, which in turn will stimulate feed grain consumption, but that too is unlikely to grow as rapidly as in the past. Much of the increase in meat demand in recent years came from the People's Republic of China (hereafter "China"), but consumption there now compares with that in high income countries. In the medium term, it is unlikely that other regions can provide demand growth for meat comparable to that provided by China over the past two decades. For example, the latent demand for protein in India is likely to be met mostly by dairy products. Over the long term, a major stimulus to world food markets could come from per capita demand growth in Sub-Saharan Africa, although in many of these countries economic growth is currently not resulting in higher disposable income for the majority of the population. Globally, as incomes increase and lifestyles change, a growing preference for processed food products will tend to support the demand growth for sugar, dairy, and vegetable oil, albeit at slower rates than in the past. Furthermore, while biofuels contributed to demand growth for cereals, sugarcane and vegetable oil over the past two decades, the contribution of biofuels to demand for agricultural products will be much smaller in the coming years if current trends continue (OECD/FAO, 2020[5]).

Figure 1.2. Annual growth in demand for major agricultural commodities



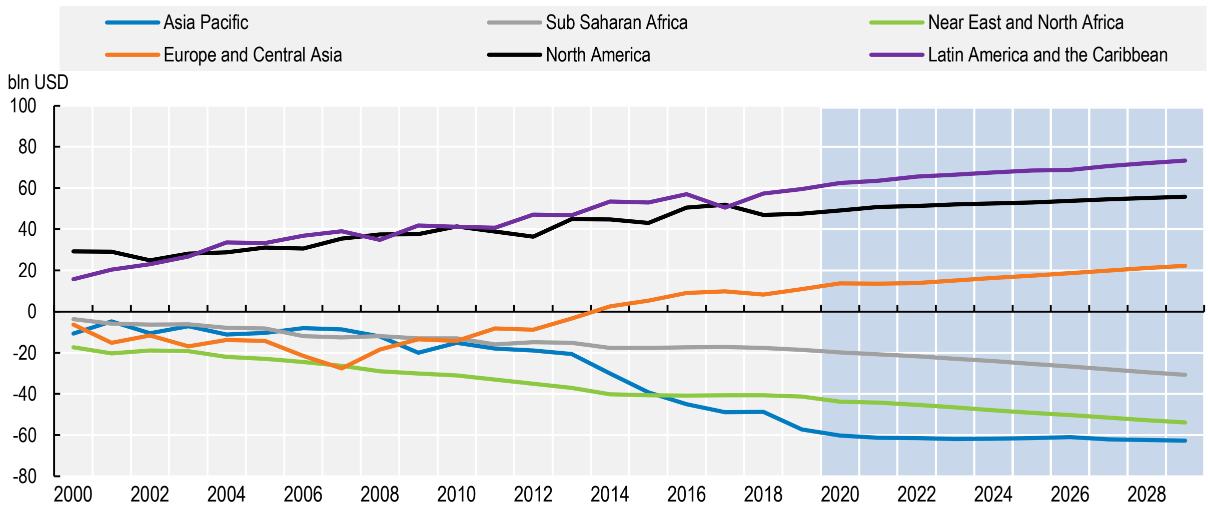
Note: Growth rates refer to total demand (for food, feed and other uses).
Source: OECD/FAO (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

On the supply side, the growth in agriculture and food production in the past decades has increasingly come through higher yields rather than through the use of more land. The growth in yields in turn reflects the use of other inputs (such as fertilisers), but increasingly output growth is driven by efficiency gains, e.g. through better farm management practices (Section 1.4). Large yield gaps exist around the world, and some regions (notably Sub-Saharan Africa) have considerable scope to raise yields to meet rising demand. Further production growth in major exporting regions (such as North and South America, Russian Federation, and Ukraine) is also expected to contribute to supply growth.

As the regions experiencing the greatest increase in population and food demand are not those with the greatest potential for supply growth in the short-to-medium term, international trade will become increasingly important for global food security by balancing the deficits of net food importers with the surpluses of net food exporters (Figure 1.3) (OECD, 2013[6]). In some countries, food imports are high partly because of low agricultural productivity. Closing yield gaps in Sub-Saharan Africa could significantly reduce the region's food import bill. Cross-border and intra-regional trade has the potential to improve food availability, especially in countries where deeper integration with world markets remains difficult. Trade can only fulfil this role if imports are affordable for consumers, which depends on various domestic factors which can raise prices (from import tariffs to poor infrastructure), on consumers' disposable incomes, and on the evolution of agricultural commodity prices in international markets.

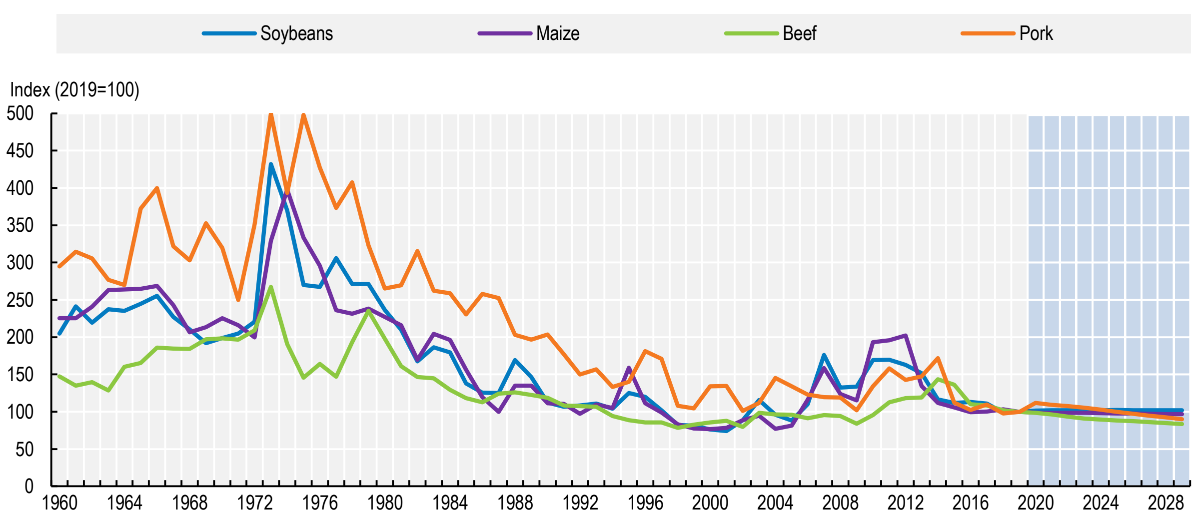
With global demand growth decelerating and broadly matched by supply growth, real agricultural prices are projected to remain flat to declining on average over the next ten years (Figure 1.4). However, markets are subject to shocks. In some instances, such shocks cause temporary periods of rising prices and high volatility, as seen on cereal markets in 2007-08, or disruptions in the functioning of global supply chains, as seen during the COVID-19 crisis. National markets can also be subject to catastrophic events such as harvest failures, which require effective risk management policies. International trade has an important role to play in buffering against such national risks. These issues are taken up below.

Figure 1.3. Agricultural trade balances by region



Note: Net trade (exports minus imports) of major agricultural commodities, measured at constant 2004-06 USD.
Source: OECD/FAO (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Figure 1.4. Long-term evolution of real agricultural prices



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 (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Yet overall, global food availability is not likely to be a constraint in absolute terms. Ongoing food shortages are most likely to derive from factors such as conflict and civil unrest; in some isolated areas, ensuring food availability may also be challenging because of high transport costs. At the global level, however, a relative abundance of supplies will probably keep food prices low, thereby also helping to improve the affordability of (and hence access to) food.

In short, it seems likely that food systems globally are able to meet the growing demand for food. The real question is how food availability can be increased sustainably. This can be done by policies that increase supply sustainably, and by policies that limit or reorient food demand.

Policies to increase food supply in an environmentally sustainable way

Increasing the supply of food through either agricultural land expansion or a more intensive use of other inputs (e.g. water, fertilisers) can have important negative environmental effects, as discussed in more detail in Section 1.4. What is needed instead is sustainable productivity growth, both in primary agriculture and throughout the food chain. Policy makers have an important role to play in achieving this outcome (OECD, 2019[7]).

Research and development (R&D) policies will play a key role in improving productivity in agricultural production, food processing, and delivery to consumers. This requires public investments as well as effective and predictable regulation of new technologies, including biotechnology and digital technologies. For example, new breeding techniques can accelerate the productivity and climate resilience of both crop and animal agriculture in the decades to come (see, for example, South et al. (2019[8]), Van Eenennaam (2017[9])), but private sector investment will be limited if there is uncertainty about the future regulatory environment. Public investments in agricultural R&D have historically had large positive effects on agricultural productivity (Alston et al., 2010[10]). Despite this strong track record and the clear need for innovative solutions to meet the triple challenge, public funding for agricultural R&D has been falling in real terms over the past decade in high-income countries (Heisey and Fuglie, 2018[11]). Public funding for research on food and agriculture is crucial in areas where private investment is missing. So are efforts by developed countries to share technology with developing countries.[8] Public policy can also stimulate private efforts, including through public-private partnerships (OECD, 2019[7]).

Innovation is only effective if new technologies are widely adopted, which requires education, training, and advisory systems. Especially in the developing world, there may be multiple barriers to obtaining and adopting new technologies by farmers, such as lack of credit, lack of reliable information, poor quality of the available technology, or barriers to business expansion (e.g. land tenure systems and gender barriers). The deeper integration of smallholders into domestic and potentially international value chains could help overcome some of these constraints (Swinnen and Kuijpers, 2019[12]). Digital technologies could also help in dealing with the risks created by climate change and in achieving sustainable intensification (OECD, 2019[13]).

New technologies make it possible to achieve more output with fewer inputs, but even with existing technologies much can be done to improve the sustainability and productivity of global agriculture. Many agricultural and economy-wide policies lead to a misallocation of resources and have negative environmental effects (Section 1.4). One example is policies which fail to correctly price water resources for farmers (Gruère, Ashley and Cadilhon, 2018[14]). Other policies keep farmers in low-income activities, stifle innovation, slow structural change, and weaken resilience. Rolling back these policies would contribute to sustainable productivity growth, but may also accelerate adjustment and consolidation at the farm level, along with the associated release of labour from the sector (Section 1.3).

Improving the overall efficiency of the food chain can help increase food supply by reducing losses that occur between the harvest and retail stages. These losses have been estimated at 14% of global food production, although rates seem to vary strongly even within the same region and commodity group (FAO, 2019[15]). Losses occur in both developed and developing countries, and the underlying causes are likely to be context-dependent. In developing countries, losses are likely due in large part to inadequate infrastructure such as poor transportation systems (roads, railways, ports, etc.), a lack of storage facilities (in particular refrigerated storage), and unreliable utilities (power and water). However, better monitoring and quantification is essential to develop more tailored policy interventions and to better understand the costs and benefits of different policy options (FAO, 2019[15]).

The above policies have the twin benefit of increasing food availability while improving economic efficiency, in contrast with other policies that may boost food availability but do so with highly inefficient instruments. In particular, high import tariffs and subsidies linked to production or to the use of agricultural inputs may boost domestic food supplies, but lead to a misallocation of resources, reduce overall national welfare, and generate negative spill-overs on international markets. They are also inefficient ways of raising farmers' incomes, are more difficult to target than direct payments, and can have negative environmental consequences (OECD (2002[16]), (2019[17])).

Policies to limit or reorient demand growth

On the demand side, several policy options exist to limit or reorient the demand for food, thus providing a complementary path to increasing food availability sustainably. Broadly speaking, four categories of policy lever exist: reducing overconsumption of food; reorienting diets towards more sustainable patterns; reducing food waste; and limiting the growth in "non-food" demand for agricultural commodities.

First, in many countries, both developed and developing, a significant share of the population consumes more calories than the medical evidence suggests is healthy. Bringing these consumption patterns in line with dietary recommendations would thus limit the growth in food demand.

Second, moving towards healthier diets will often involve not only a reduction in calorie intake but also a change in the composition of diets, which can in turn reduce pressures on the environment. A move towards healthier diets (e.g. as defined by national dietary guidelines) would for many countries imply more moderate levels of consumption of meat and dairy products (although in lower income countries, where per capita demand remains below recommended dietary limits, it would imply an increase in consumption). Healthier diets would typically also involve higher consumption of fruits and vegetables and reduced consumption of sugar and of vegetable oils that are high in trans fats (WHO, 2018[18]). Not all of these changes are unambiguously positive for the environment; for example, fruit production tends to involve relatively high pesticide use, and in some contexts increasing the production of fruits and vegetables may increase pressure on water resources. But on balance, a move towards healthier diets could reduce the pressure on resources needed by agriculture to meet future food demand. Another way to improve environmental sustainability is to increase transparency and traceability along the food chain to allow customers to identify and buy more sustainably-produced food. Advances in digital technologies may help in this regard (Jouanjean, 2019[19]).

Third, efforts to reduce food waste could significantly improve food availability without expanding production, thus avoiding additional environmental pressures (Bagherzadeh, Inamura and Jeong, 2014[20]). In developed countries, a significant amount of waste can occur in the retail and food service parts of the food system, as well as at the consumer level. In the United States, for example, an estimated 31% of the total supply of food was lost at the retail and consumer level in 2010 (Buzby, Wells and Hyman, 2014[21]). Sources of waste include cooking loss and spoilage due to inadequate storage after purchase, plate waste from meals consumed in restaurants or in the home, and restaurants over-ordering so that they can maintain a diverse menu. Yet, while food waste corresponds to a monetary loss for households, the fact that food continues to be wasted suggests that other factors, such as convenience, play an offsetting role in household decision-making. For example, while reducing food waste may save money it is likely to impose some non-monetary costs, such as an investment of time and energy in learning how to prepare meals from leftover food and recurring efforts to more carefully plan meals. As individual decisions do not take into account the true environmental cost of food waste, there is a rationale for public efforts to reduce waste (FAO, 2019[15]). Efforts to raise awareness and visibility and other policies that target consumer behaviour changes may be effective ways to reduce this type of waste without generating spill-overs across other dimensions of food security. At the same time, factors such as the time and effort needed for better meal planning suggest that behavioural change may not be straightforward.

A fourth way to reduce demand-side pressures is to limit growth in "non-food" demand for agricultural commodities. Over the past two decades, the main source of growth in this demand has come from the expansion of biofuels, stimulated by policies in many countries which mandated a minimum level of biofuels to be blended with conventional transport fuels. Biofuels from non-food agricultural sources are expected to be a necessary component of global efforts to combat climate change. However, policies that encourage the use of food or animal feed products as feedstocks for biofuels should be avoided in the absence of clear evidence of the gains in terms of reduced net GHG emissions (OECD, 2019[22]) (OECD, 2013[6]) (OECD, 2008[23]).

Finally, international trade can help improve the "matching" of supply and demand. Trade not only enables food to move from surplus to deficit regions, but will be necessary to ensure the efficient and sustainable use of global food and agricultural resources. However, import tariffs for agricultural goods remain higher than for industrial goods, creating distortions which limit this "matching" function of international agricultural trade (OECD, 2019[24]).

Access to food

In contrast to food availability, the determinants of access to food lie mostly outside the food system. Food prices clearly matter for the affordability of food, but overall real incomes remain a much more important factor: where incomes are extremely low, even cheap food may be out of reach, let alone a balanced diet necessary for a healthy and active life (Hirvonen et al., 2019[25]). In the early 2000s, when international food prices were at all-time lows, there were more than 800 million undernourished according to FAO estimates (FAO, 2020[26]). By contrast, income growth typically leads to a decrease in childhood stunting, an indicator of chronic childhood malnutrition (Headey, 2013[27]).

Conflict and civil strife can rapidly undermine access to food, as shown in recent years. Beyond that, resolution of the paradox of hunger amid plenty is fundamentally about raising the incomes of the poor rather than lowering food prices. For poor consumers in developing countries, much of this is about broad-based economic development. Food systems are implicated to the extent that they are a driver of economic development and a source of livelihoods (Section 1.3).

In some cases, there is a more direct link between food availability and access. While much of the world's food is produced by larger commercial farms (where the food security of the operators is not in question), the basic food security of many smaller farmers is contingent on the income they derive from agricultural production and the food they produce for own consumption (HLPE, 2013[28]).

The problem of food access is not confined to poor countries: food insecurity also exists in high-income countries, where in recent years an estimated 60 million people (or 7% of the population) used food banks (Gentilini, 2013[29]). In several high-income countries, remote and indigenous groups are particularly vulnerable (OECD, 2019[30]) (Davy, 2016[31]). The origins of this problem include low incomes, social exclusion, and remoteness. Policies designed specifically for food systems may thus not be sufficient to resolve the problem, and a broader set of policies may be needed.

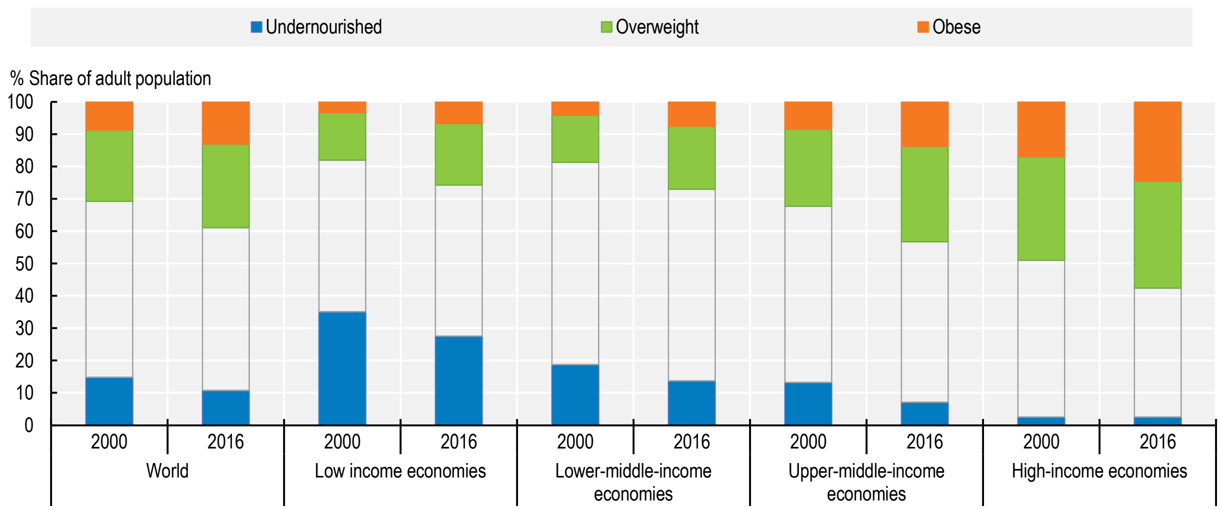
Nutrition in support of public health

Increased food availability and improved access are necessary conditions for improvements in food security and nutrition, but they are not sufficient to guarantee improved nutritional outcomes.

As countries develop economically, they typically pass through a "nutrition transition", under which higher incomes translate first into demand for more calories, and then into demand for more protein (usually from animal sources) as well as for other nutrients coming from nuts, fruits and vegetables. A parallel trend is for higher consumption of sugar, oils, and fats, via processed foods. These become more important as countries become wealthier and more urbanised (Popkin and Gordon-Larsen (2004[32]), Popkin (2017[33])).

Up to a certain point, the consumption of more food from more diverse sources improves nutrition. But many parts of the world are seeing a rising burden of overweight and obesity (Figure 1.5).

Figure 1.5. Undernourishment, overweight and obesity, 2000-2016



Source: WHO (2019)

Many developing countries have poor nutrition, with people who are undernourished (having insufficient calories), over-nourished (having too many), and malnourished (as a result of not having the right balance of nutrients). Many poorer countries lack the necessary complements to ensure effective nutritional outcomes, such as clean water, public health, and specific nutrition assistance, in particular for mothers and young children (Global Nutrition Report, 2018[34]) (Pingali and Sunder, 2017[35]).

Developed countries mostly have more stable food preferences, with incomes growing more slowly and consumption patterns that are less sensitive to income changes. These patterns typically include a high intake of meat and dairy products, as well as vegetable oils and sugar (due in part to the consumption of more processed food products). However, there is increasing over-consumption, which translates into a higher proportion of the population being overweight or obese: almost one in four people in OECD countries is obese (OECD, 2019[36]). Ultra processed foods that are low in nutritional content but dense in energy now make up 30-60% of total dietary energy consumed in high-income countries.[9]

Poor nutrition in all its forms leads to poor health outcomes (Afshin et al., 2019[37]). For example, poor diets contribute to type 2 diabetes (Ley et al., 2014[38]) and the nutrition transition has coincided with a strong increase in the prevalence of diabetes worldwide, with the strongest growth in low- and middle-income countries (NCD Risk Factor Collaboration, 2017[39]). Overweight and obesity are linked to a range of such non-communicable diseases and shorter lifespans (NIH, 2013[40]), imposing considerable costs on society (OECD, 2019[36]). A systematic analysis by the Global Burden of Disease Study suggests that 11 million deaths globally were attributable to dietary risk factors in 2017, with the three leading risk factors being high intake of salt, low intake of whole grains, and low intake of fruits (Afshin et al., 2019[37]). The same analysis finds that improved diets could prevent one in five deaths globally. In addition to causing preventable deaths and poor health outcomes, inadequate nutrition affects livelihoods by reducing labour productivity and hence incomes. Global economic losses due to various types of malnutrition (including undernutrition and obesity) have been estimated at 4%-5% of global GDP (FAO, 2013[41]).

Dietary guidelines around the world typically recommend consuming a variety of foods, including fruits and vegetables, legumes, and animal-source foods (meat, eggs, dairy), while limiting sugar, fat, and salt intake.

Recommendations on intake of dairy, red meat, fats and oils, and nuts are more variable (Herforth et al., 2019[42]). In developed countries, guidelines often recommend limiting the consumption of high-fat dairy products and meat, especially of processed and/or red meat.[10]

The causes of unbalanced diets, when the prerequisites of availability and access are met, are complex (OECD, 2019[36]) (Alston, MacEwan and Okrent, 2016[43]). Increased urbanisation and greater female participation in the workforce are two factors behind the increased consumption of processed food and growing tendency to eat outside the home (Bleich et al., 2008[44]) (Seto and Ramankutty, 2016[45]), while increased sedentariness is a further factor behind rising obesity trends (Graf and Cecchini, 2017[46]). A lack of affordable and healthy food options ("food deserts") or a high proportion of fast food outlets ("food swamps") have been suggested as contributing factors. Research in the United States suggests that lack of access to healthy food is not a major factor (Ver Ploeg and Rahkovsky, 2016[47]) although proximity to fast food outlets seems to be a better predictor of obesity rates (Cooksey-Stowers, Schwartz and Brownell, 2017[48]).

Recent OECD work suggests that a four-track approach can encourage healthier food choices in a way that is consistent with wider objectives for the food and agriculture sector, including objectives related to environmental sustainability and to the livelihoods of agents along the food chain (Giner and Brooks, 2019[49]).[11]

The first track would be to tackle unhealthy food choices via demand side public interventions such as the provision of public information and counselling, including through the use of digital tools (Baragwanath, 2021[50]). Such instruments do not introduce other distortions into the functioning of the food system. The evidence base suggests that such policies work and are cost-effective, but are unlikely to be sufficient. A particular need is to target groups with poorer diets, which requires an understanding of the socio-economic and demographic aspects of food choices (Placzek, 2021[51]).

A second supporting track is to work with industry at the supply-demand interface, e.g. in product reformulation or in introducing and testing labelling schemes.[12] There is an emerging evidence base that such policies can be effective, but that specific design features are critical for their success. Simplified labelling schemes offer considerable potential, with a need for international cooperation given the global nature of the food industry. A potential avenue for public-private collaboration is through behavioural nudges. The scope for testing the effectiveness of such approaches is enhanced by digital technologies and associated possibilities to collect information on consumers' food acquisition and intake, as well as on the food environment more generally (Baragwanath, 2021[50]) (OECD, 2019[13]).

As a third track, some firmer regulations may be needed to modify processors' and retailers' behaviour, as private incentives do not always fully align with public ones. Such measures could include rules on promotion and advertising for foods which are potentially unhealthy, such as those rich in sugar, salt and/or fat. Restrictions are especially relevant for products marketed to children. For example, UK Advertising Codes restrict promotion of products high in fat, salt, or sugar to children.[13] Regulations can also directly address product composition. The World Health Organization has called on governments to eliminate industrially-produced trans fats from the global food supply, and bans on trans fats are in place in a growing number of countries (Health Canada, 2018[52]).

A fourth track is fiscal measures, including consumption taxes on products that are "unhealthy" when consumed excessively.[14] Such policies may have some effect, but with low price elasticities of demand, taxes would need to be very high to have a sizeable effect on consumption. They are prone to slippage (e.g. with consumers sourcing from other markets) and may be regressive in terms of their higher impact and incidence on those with lower incomes. Given alarming trends in public health, and the fact that other instruments have so far not managed to reverse those trends, policy makers are giving increased consideration to such measures. A particular target has been sugar, where consumption levels often largely exceed those recommended by health experts, and where current trends are pointing in the wrong direction. The announcement in the United Kingdom of a levy on soft drinks resulted in several major companies reformulating their products ahead of the introduction of the tax (Davies, 2019[53]), suggesting that a credible threat of policy action can play an important role in prompting change and may be as important as the action itself.

Across these four different policy approaches, further research will be needed to determine which combinations of instruments are likely to be most effective. More information is needed, in particular, on products provided by the fast growing catering industry and on the characteristics of food consumed away from home.

Stability

Complete food security requires stability across the availability, access and utilisation dimensions. There is a need to build resilience into the food and agricultural system in order to manage a wide range of risks. Many of the core policies that are needed to help the system withstand short-term shocks are the same as those needed to improve long run productivity. But other measures can be taken to deal with short-term variations in food availability and prices.

On balance, domestic shocks tend to be more frequent and more severe than international shocks. For this reason, international trade plays an important role in reducing volatility by enabling countries to make use of world markets in the face of domestic shocks (OECD, 2013[6]). Improvements in infrastructure (transportation and storage) and transparency regarding supply, demand, stocks, and prices can contribute to the effectiveness of trade. International initiatives such as the G20-led Agricultural Market Information System (AMIS) can play an important role in the assembly and diffusion of accurate information.[15]

The buffering function of trade also requires that countries avoid the use of policy measures that undermine the efficient functioning of international markets. In 2007-08, in the face of rapidly rising food prices, a number of key grain exporting countries adopted export restrictions or bans in an attempt to reserve domestic production for local consumption. At the same time, several major grain importing nations reacted by increasing bids for import supplies, reducing pre-existing import restrictions such as tariffs and relaxing tariff rate quotas (Jones and Kwiecinski, 2010[54]). These types of actions contribute to instability in international markets, with consequent negative implications for global food security. In practice, many agricultural markets are “thin”, and world cereal trade achieves only a fraction of its potential risk pooling benefits (Liapis, 2012[55]). With climate change, and an increased likelihood of extreme events, the risk pooling effect of trade will become more important. There is thus a case for further trade liberalisation to “thicken” international markets and to enable trade to play its balancing and stabilising role.

Openness may not be sufficient to contain rare but severe international shocks, such as simultaneous harvest failures, or disruptions to global supply chains as during the COVID-19 crisis. Countries need mechanisms to manage such risks, but border measures are not a co-operative way to do so, and self-sufficiency policies increase risks to domestic food security from unforeseen variations in domestic production. Yet, trade policy instruments are often used by governments to try to influence the stability of domestic markets. Asian rice producing and consuming countries have a long history of using price policies and border measures to stabilise domestic prices (Timmer, 2010[56]). Interventions in Africa have often destabilised domestic markets (Jayne and Tschirley, 2009[57]). For the world as a whole, domestic trade policy interventions appear to have had little impact on reducing domestic price instability (Anderson and Nelgen, 2012[58]). The use of trade measures to insulate economies from shocks to world prices can, at best, transfer the risks associated with commodity production and trade. If many countries seek to transfer price risk to others, the outcome is likely to be ineffective (Martin and Anderson, 2011[59]).

Public stock policies can be used to help stabilise domestic food markets. It is important to distinguish between three major types of public stocks (Deuss, 2015[60]). Emergency stocks are only released in response to humanitarian emergencies. Social safety net stock schemes distribute food at subsidised prices in order to assist the impoverished and chronically food insecure. Buffer stocks aim to stabilise prices and/or affect the level of producer and consumer prices. However, it is not clear that such storage programs reduce domestic price volatility, and even if they do, this is often at a high cost. Moreover, public stockholding policies are almost always implemented via other policy instruments such as administered prices, trade policy instruments, and import and export monopolies, which create economic inefficiencies. Policies to support prices for farmers also often lead to the accumulation of stocks. There are also concerns about spill-overs on international markets through the impact of the accumulation and release of stocks.

In the rare but potentially disastrous scenario of a severe international shock, the priority is to ensure that poor countries are provided with the means to maintain food availability and access. Food assistance under the terms of the 2012 UN Food Assistance Convention may help with local availability in response to humanitarian emergencies.[16] For rare cases of aggregate calorie shortfalls when food import bills become unaffordable, there are under-utilized mechanisms for financial assistance to buy food (Brooks and Matthews, 2015[61]). These are, in most cases, preferable to physical food aid. Governments may also use option contracts to lock in future food import purchases, so that future import costs are known in advance. Increased international assistance – financial and technical – may be required to help put these mechanisms in place.

Well-regulated futures markets provide a means for food systems participants to reduce price risk through hedging or the purchase of options, and also provide an important source of information on prices for decision making by those participants (FAO et al., 2011[62]). Insurance products, e.g. crop insurance, can play a role in increasing resilience in the food system, particularly in the face of increasing climatic variability. Such products need to be actuarially sound, i.e. not become ways for governments to provide subsidies to farmers. Subsidised insurance has the potential to cause resource misallocation by promoting the production of climatically vulnerable products or production in areas subject to high climatic risk.

1.3. Challenge 2: Livelihoods

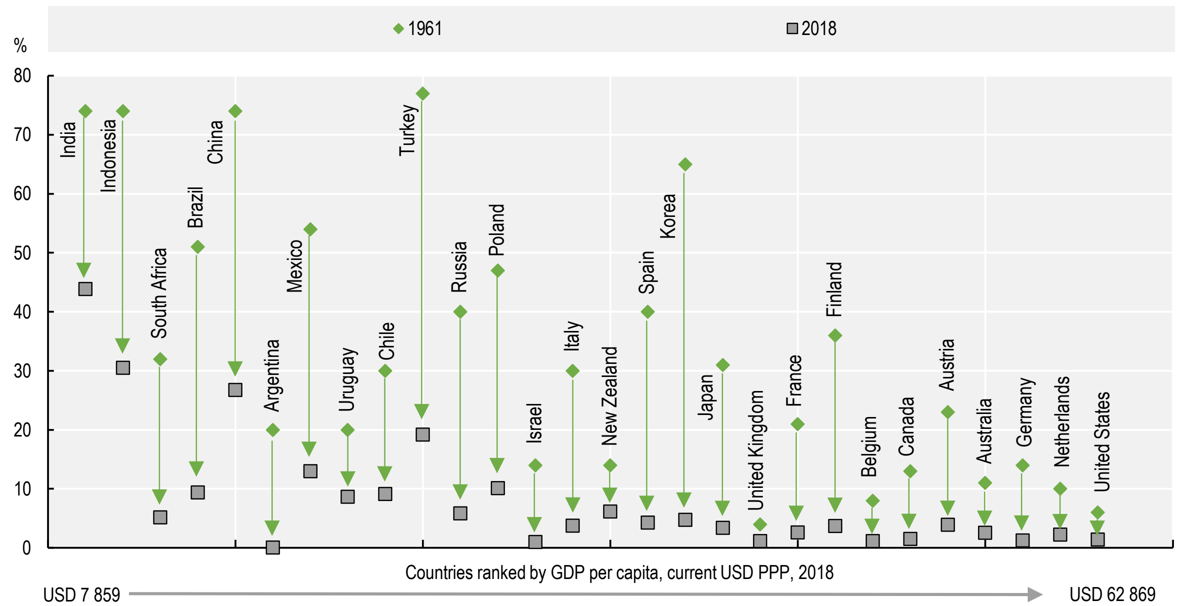
Economic development and the transformation of food systems

Food systems provide incomes and livelihoods to farmers and many others in the economy, ranging from input suppliers to those engaged in downstream processing and distribution, as well as the final stage of supermarkets, canteens, food stalls and restaurants. A multitude of service sectors are connected to the supply chain. Many of those services are provided locally, often giving a rural dimension to food systems development.

Primary agriculture is the basis of the food system, and employs a large number of people directly. Most of the world's farmers are smallholders: of the more than 570 million farms worldwide, an estimated 500 million (84%) are small farms of less than 2 hectares (Lowder, Skoet and Raney, 2016[63]). These small farms produce an estimated one-third of global food supply (Ricciardi et al., 2018[64]) with the remaining two-thirds produced by larger farms, most of which are family farms rather than corporate farms (Lowder, Skoet and Raney, 2016[63]). Livestock plays an important role in providing livelihoods for many rural households (FAO, 2018[65]); the case study on ruminant livestock explores this sector in more detail.

As economies develop, primary agriculture tends to account for a declining share of overall employment (Figure 1.6). Associated with this are often huge rural-to-urban migrations. There are two main reasons for this. On the supply side, labour-saving productivity growth in agriculture tends to consolidate farming, pushing farmers and farm workers out of the sector. On the demand side, faster rates of non-agricultural growth compared with agricultural growth pull agricultural labour into other sectors. The adjustment process is naturally easier to manage when those two forces are matched.[17]

Figure 1.6. Agriculture's share of total employment, 1961-2018



Source: Agriculture's share of employment from World Development Indicators; GDP per capita data from the IMF.

Smallholder farmers are directly implicated in the agricultural transformation. In agriculture-dependent economies, the development process has to start by exploiting the potential of existing structures, and productivity and income growth in agriculture can be essential in generating demand for manufactures and services (Timmer (2002[66]); Olmstead and Rhode (2008[67])). Over the longer term, however, the improvements in productivity needed to assure higher incomes go hand-in-hand with large reductions in the proportion of the population engaged in agriculture.

The specificities of this development process vary across countries. Some countries may retain a higher share of employment in farming than overall incomes would suggest because of their comparative advantage in agricultural production. For instance, dairy farming and processing alone account for 3% of GDP and employment in New Zealand (NZIER, 2018[68]). Some countries may also be relatively specialised in more labour intensive commodities such as fruits and vegetables. The speed of the development process also differs: the pace of non-agricultural growth in Southeast Asian countries has been so fast over recent decades that the absorption of labour from agriculture has occurred much more swiftly than it did in Europe or earlier developing regions. In some developing countries (particularly in Sub-Saharan Africa), that process is still at an early stage, and there are concerns about premature de-industrialisation thwarting a smooth transition.[18]

When jobs are created outside of agriculture, these are often still connected to the food system. For instance, as urbanisation and income growth contribute to a greater consumption of processed foods bought from both small and large retailers, employment opportunities are created in food processing and retailing (Reardon and Timmer, 2012[69]). Employment in the food chain thus tends to shift from agriculture to other segments of the food chain as countries develop. In low-income countries (e.g. in Eastern and Southern Africa), some 90% of the food-related employment is in agriculture. In middle-income countries such as Brazil, farming accounts for around half of the food-related employment, with the remainder split between food services (including, for example, logistics) and food manufacturing. In high-income countries such as the United States, around two-thirds of the food-related employment is in food services (World Bank, 2017[70]). The data also suggest that as economies develop, agriculture's share of GDP falls from

40% of GDP or more to below 10%, while the share of agribusiness (i.e. all other segments of the food chain) grows from less than 20% to more than 30%, before declining again as countries become more industrialised (World Bank, 2008[71]). However, even in industrialised countries food-related activities remain important: food and beverage manufacturing ranks as one of the top three manufacturing activities in terms of value added in 27 OECD countries (UNIDO, 2020[72]).

International trade and participation in global value chains (GVCs) are important drivers of agricultural employment and incomes around the world. Trade directly or indirectly accounts for around one-fifth of agricultural labour income globally, albeit with important variation among countries: in New Zealand, close to 73% of agricultural labour income depends on value added created by trade and GVCs, while this share is only 3% in Japan (Greenville, Kawasaki and Jouanjean, 2019[73]). These figures include both the direct effect of agricultural trade and the indirect effect of trade in products which rely on agriculture. Indeed, trade in agro-food products also generates income in other sectors, such as industry and services: globally, around one-fifth of the labour income created by agro-food exports goes to the services sectors supporting the production of primary and processed products, with another 6% going to labour used in industry (Greenville, Kawasaki and Jouanjean, 2019[73]).[19] Countries also do not necessarily need to move into food processing to generate higher value-added: participation in international trade and GVCs (i.e. through the export of primary products) can generate at least as much domestic value added as participation which relies on domestic processing (Greenville, Kawasaki and Jouanjean, 2019[74]).

Productivity improvements in agriculture have underpinned a long-term trend towards declining real agricultural prices. This has provided major benefits to consumers all over the world, but puts direct pressure on the incomes of poorer farmers. At the same time, consumers are shifting their spending from relatively unprocessed products bought in local markets to processed foods bought in supermarkets or meals consumed away from home. Spending on food must now not only cover the costs of agricultural ingredients but also the costs incurred by other actors in the food chain, from logistics providers to chefs, from employees in slaughterhouses to check-out clerks in grocery stores. In combination with declining real agricultural prices, this results in a declining "farm share" of food expenditures. This decline is sometimes interpreted as evidence that farmers are systematically disadvantaged relative to other actors in the food chain. However, the observed changes in the "farm share" largely reflect the structural changes described earlier. In the United States, for instance, the farm share of the food dollar was estimated at less than 15% in 2018. But nearly half of the US "food dollar" goes to paying salaries in sectors other than primary agriculture – notably in food service, retail, and food processing.[20] Rather than measuring market power, the "farm share" therefore mostly reflects structural changes occurring in the food system.[21]

A trend underlying much of the structural transformation occurring in agro-food systems in recent decades is the increasing importance of standards, labelling, and certification to create more differentiated products (Beghin, Maertens and Swinnen, 2015[75]). Meeting these standards imposes more stringent requirements on participants in the value chain (Fulponi, 2006[76]). On the other hand, if consumers are willing to pay a premium for these products, the resulting value can in principle be shared along the value chain – and such value-sharing with suppliers may be necessary to ensure a stable supply of products that meet the desired criteria (Swinnen et al., 2015[77]) (Sexton, 2013[78]). Some certification schemes, such as Fairtrade, explicitly aim to improve farmers' livelihoods. Empirical evidence on how these developments impact farmers is currently mixed.[22] However, it is possible that new digital technologies enabling greater transparency and traceability could make it easier for farmers to provide differentiated products to customers.

Policies to strengthen livelihoods across food systems

In broad terms, the process of labour adjustment has been positive (OECD, 2012[79]). Agricultural production continues to grow in most countries, implying continued economic opportunities within the sector, even if labour demand is declining relative to that in other sectors. Millions of people have left agriculture for higher paying jobs while their offspring have benefited from superior opportunities in other sectors. For educated children, the transition has frequently offered a large improvement in earning potential. But the process of adjustment has been far from seamless. It has involved stresses too, with less competitive farmers struggling to compete as productivity growth lowers real farm prices, and cases of distress migration from the fields to urban centres. Policies need to enable people to take advantage of the rising opportunities offered by agricultural development, but also protect those who are unable to do so.

OECD work has emphasised the need for a long-term strategy for development that acknowledges the inevitability of structural change while helping to smooth the adjustment process (OECD, 2012[79]). Such a strategy should offer multiple pathways that include (i) increasing productivity and competitiveness within agriculture; (ii) diversifying income sources, within or outside agriculture; and (iii) leaving the sector for off-farm employment. At the same time, governments will need to provide social protection for those unable to adjust.

OECD (2012[79]) provides recommendations on the instruments that can facilitate transition along these pathways, highlighting the role of productivity-enhancing investments for those who remain in the sector, and a role for agricultural risk management policies that underwrite those aspects of agricultural risk that neither farmers nor markets can cover (OECD, 2011[80]). Wider investments in human capital, hard and soft infrastructure can improve households' opportunities without biasing decisions on whether to remain in the sector or take advantage of opportunities outside agriculture, while labour market and regional policies can facilitate the absorption of labour into other sectors, including downstream processing sectors.

So far, the bulk of policy support to agriculture has not been calibrated in ways that correspond to the balance of economic opportunities across these pathways. Total support to agriculture (including support to farmers, general services to the sector and consumer subsidies) across the 54 countries covered by the 2020 *OECD Agricultural Policy Monitoring and Evaluation* report (OECD, 2020[81]) averaged USD 708 billion per year in 2017-19. A relatively low share of this support was provided in the form of "general services" to the sector, a category which includes public services such as R&D support and inspection services (Figure 1.10). Nearly three-quarters (USD 536 billion per year) was provided in the form of support to farm incomes, either via higher prices or direct payments, as opposed to the enabling environment through which those incomes are generated. Such support has the effect of providing a disincentive for farmers to diversify their income sources or leave the sector, thereby putting a brake on – rather than facilitating – adjustment pathways beyond agriculture.

Beyond the agricultural sector, many countries provide social safety nets, including conditional cash transfer programmes, but few have provided at-scale programmes to smooth the absorption of ex-farmers in the non-agricultural economy or to manage rural-urban migration.

1.4. Challenge 3: Environmental sustainability

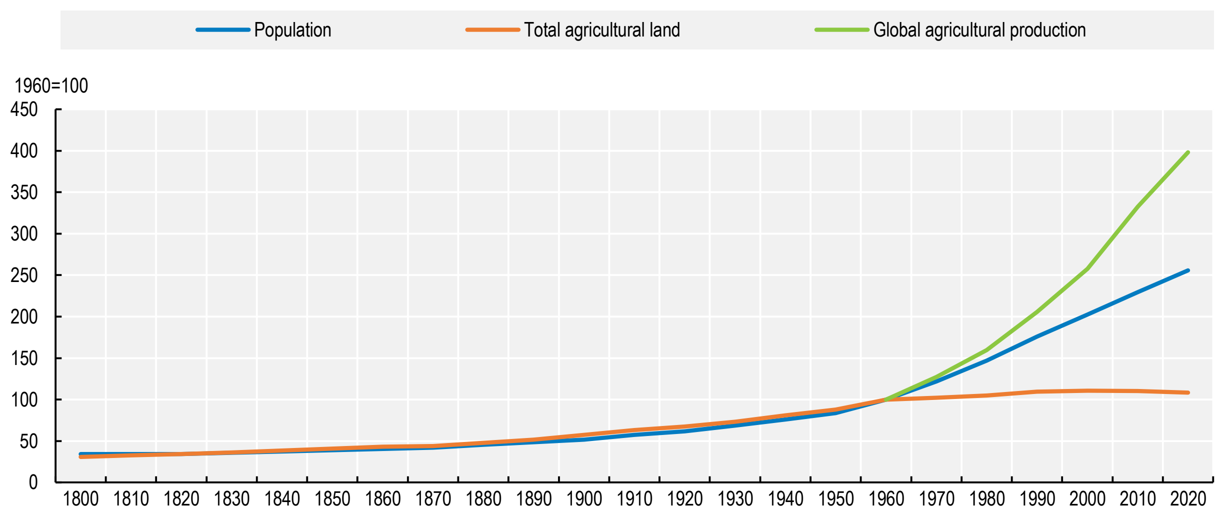
Food production has led to environmental changes such as deforestation, erosion and resource depletion since the rise of agriculture (Kirch, 2005[82]), but environmental pressures from agriculture have accelerated in the past two centuries as the world population grew from 1 billion in the early 1800s to more than 7.5 billion today. As a result, agricultural production is currently a major source of environmental pressures, not only in local ecosystems but also at a global level (Campbell et al. (2017[83]), IPBES (2019[84]), IPCC (2019[85])).

Due to its close link with the natural environment, much of the environmental damage related to food systems occurs at the agricultural production stage. This is true not only for impacts on land use, biodiversity, or water use, but also for greenhouse gas (GHG) emissions. Agricultural production and the associated land use changes account for an estimated 16-27% of total anthropogenic GHG emissions while all other stages of food systems (energy, transport, processing, etc.) contribute an estimated 5%-10% (IPCC, 2019[85]).

Broadly speaking, greater food production can come from three sources, with starkly different environmental implications: greater land use, greater use of other inputs, and greater efficiency in how these inputs are used.

Historically, most of the increase in food production came from increased agricultural land use, as growing populations expanded the global area under crops and the area used for grazing animals. However, after 1960, food production more than tripled while land use grew by only 10%-15% (Figure 1.7).

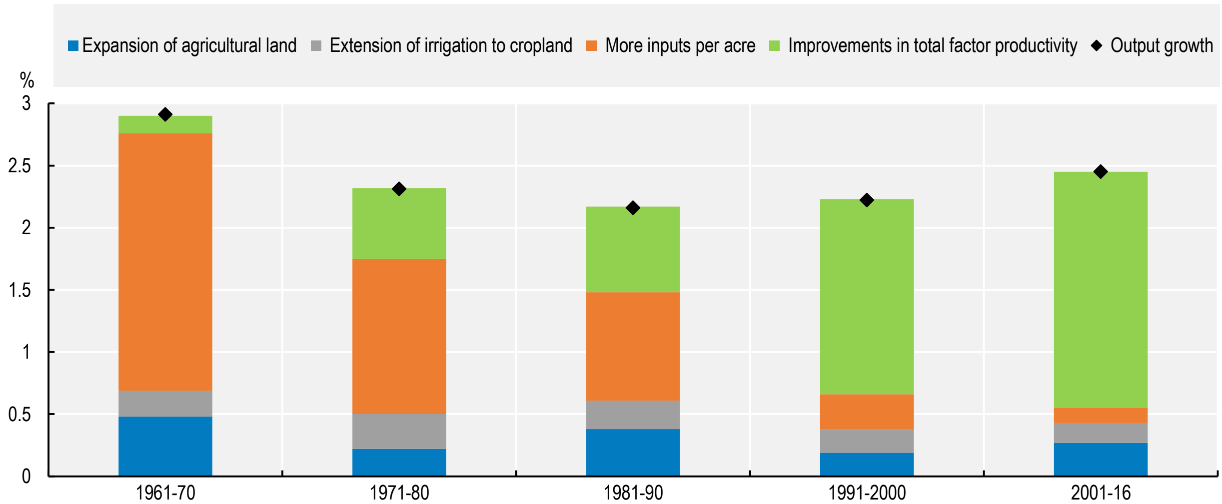
Figure 1.7. Population, food production and agricultural land use in the long run



Source: Population data from Maddison's historical statistics for 1820-1940; UN Population Division for 1950-2010; 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). Global agricultural production data for 1960-2010 from FAOSTAT (Net Agricultural Production Index); data for 2020 from OECD/FAO (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

This "decoupling" of food production and land use was initially fuelled by more intensive use of inputs, such as synthetic fertilisers and irrigation water. In recent decades, production growth has increasingly come from greater efficiency, which makes it possible to produce more with fewer inputs. Figure 1.8 shows the contribution to global agricultural output growth of greater land use, the expansion of irrigation, more intensive use of inputs (including labour and machinery, but also fertilisers, pesticides, etc.), and growth in total factor productivity, which here captures the effects of better management practices, the adoption of improved varieties and breeds, and other efficiency improvements. From the 1960s to the 1980s, the intensification of input use contributed the most to global output growth. Over time, however, total factor productivity growth grew in importance, and since the 1990s it has been the major factor driving the growth of global agricultural production.

Figure 1.8. Sources of growth in global agricultural output, 1961-2016



Note: Each bar represents the annual average per cent growth over that period.
Source: USDA, Economic Research Service, International Agricultural Productivity statistics (November 2019 revision).

Box 1.1. Fish and the triple challenge

Like agriculture, the fish and seafood sector forms part of food systems and is intimately connected to the triple challenge (FAO, 2020[86]). First, fish and seafood are important for global food security and constitute a major source of protein and essential nutrients, especially in developing countries in Southeast Asia and Sub-Saharan Africa, as well as in small island developing states (Béné et al., 2016[87]). Global per capita consumption of fish and seafood grew from 9 kg to 20.5 kg between 1961 and 2018, in large part due to demand growth in China and other Asian economies (FAO, 2020[86]). This strong increase in fish and seafood consumption was possible thanks to the rapid rise of aquaculture, which saw its contribution to global food fish consumption rise from 4% in 1950 to more than half today (FAO, 2020[86]), with expectations for further growth in the future (OECD/FAO, 2020[5]).

The fish and seafood sector is also an important source of livelihoods, with an estimated 39 million people engaged in fisheries and 20.5 million in aquaculture globally, with the vast majority based in the developing world (FAO, 2020[86]). At the same time, there is a clear challenge for sustainability. Unsustainable production practices in both capture fisheries and aquaculture as well as climate change are damaging fish stocks, aquatic and ocean ecosystems, and biodiversity. These pressures reduce production capacity in the long run. FAO estimates that the share of the world's fish stocks fished at unsustainable levels has grown from 10% in 1974 to 34% in 2017, a global average which hides significant geographical variation (FAO, 2020[86]). Data from the 2020 *OECD Review of Fisheries* on the status of stocks assessed by 31 OECD countries and major fishing economies shows that 66% had a sustainable status and 23% an unsustainable status, with 12% undetermined. The countries covered in this review tend to have more capacity for stock management, and assessed stocks tend to be intensely managed; both factors contribute to having a better status than the global average. But even so, the data shows that stock status remains an issue of concern. Moreover, about half of the stocks with a sustainable status either do not have, or are not meeting, additional management objectives (such as maximising catch volume within sustainable limits) (OECD, 2020[88]).

Unsustainable practices are caused by weak governance, inadequate management, lack of scientific evidence to support decision-making and sometimes poorly targeted support policies. For example, over the period 2016-18 the 39 countries that report data to the OECD Fisheries Support Estimate database provided USD 4.6 billion per year in direct support to individuals or companies in the fisheries sector, accounting for 4.6% of the value of marine landings. About 70% of these transfers were directed at lowering the cost of inputs, e.g. through subsidies for vessel construction or modernisation, or through policies that lower the cost of fuel which constitutes 25% of total support. OECD work has shown that such policies are among the most likely to provoke overfishing, overcapacity, and illegal, unreported and unregulated (IUU) fishing, while at the same time favouring larger fishers. Re-directing support away from such policies that create incentives to fish more intensively could have significant benefits for the environment as well as for fishers' livelihoods. Further investing in science-based management and combatting IUU fishing could have similar positive impacts along all dimensions of the triple challenge. OECD analysis has demonstrated that when an effective management system is in place (e.g. with limits on total allowable catch), support policies are less likely to encourage unsustainable fishing and generally also lead to more benefits for fishers (Martini and Innes, 2018[89]).

While the rise of aquaculture made it possible to expand the supply of animal protein for a growing world population, the growth of the sector has also created new environmental challenges (WRI, 2014[90]). Several inputs (land, water, feed, and energy) have important environmental impacts; moreover, there are problems related to disease transmission, water pollution, and safety concerns. Improvements in efficiency may make it possible to reduce the environmental impact per unit of fish produced, especially when coupled with better public planning and regulation. The environmental impact of aquaculture also depends greatly on the species farmed; a shift in demand towards "low-trophic" species (e.g. tilapia, catfish, carp) would ease pressures on the environment.

The fish and seafood sector thus exhibits many of the same characteristics as other sectors of the food system, including a close link to each of the three dimensions of the triple challenge, a policy environment which is not always conducive to meeting that challenge, and a strong connection between efficiency gains and sustainable growth. New technologies may improve monitoring and traceability along the supply chain. Moreover, as with the livelihoods challenge in other sectors of the food system, a transition towards more sustainable fish and seafood production may require investments in alternative opportunities for vulnerable populations dependent on the sector for their livelihoods.

Environmental effects of agricultural land use

Agriculture presently uses up to half of the world's ice-free land surface, far more than any other human activity and considerably greater than urban land use and other infrastructure, which accounts for around 1% of the total (IPCC, 2019[85]). Agriculture's extensive land use has come at the expense of natural landscapes and has led to the clearing or conversion of an estimated 28% of tropical forests, 40% of temperate forests, 50% of shrub land and 58% of savannah and natural grassland (Ramankutty et al., 2008[91]).

Such land use changes are a major threat to biodiversity (Newbold et al., 2015[92]). As land use by humans expands, natural habitats may be lost or degraded, or populations may be fragmented. Worldwide, around 80% of all threatened terrestrial bird and mammal species are in danger because of agriculture-driven habitat loss (Tilman et al., 2017[93]). If cropland were to expand into all suitable natural areas, there could be a potential loss in biodiversity of 30% of species richness and 31% of species abundance in tropical areas in the Amazon and Africa (Kehoe et al., 2017[94]).

The expansion of agricultural land also depletes soil carbon. When forests are converted into agricultural land, the stocks of soil organic carbon decrease strongly, with declines of around 50% in temperate regions, 40% in tropical regions, and 30% in boreal regions (FAO and ITPS, 2015[95]). Since soils hold more carbon than the atmosphere and terrestrial vegetation combined, this is worrisome from a climate change mitigation perspective; it also threatens soil fertility. A particular difficulty is that while soil organic carbon can be lost rapidly, re-carbonisation is a slow process (FAO and ITPS, 2015[95]).

GHG emissions from land use changes are a major channel through which agriculture contributes to climate change (IPCC, (2019[85]); Blandford and Hassapoyannes (2018[96]), Smith et al. (2014[97])). An estimated 44% of agriculture-related emissions in 2007-16 were due to land use change (IPCC, 2019[85]).[23]

Given the detrimental effects of agricultural land use, the fact that global food production tripled since 1960 yet required only a 10%-15% increase in agricultural land use can be considered a major achievement.[24] However, this still reflects an increase of around 450 million hectares globally, an area twice as large as Greenland. The environmental consequences have been significant, especially since this agricultural expansion largely came at the expense of tropical forests (Gibbs et al., 2010[98]). Agriculture caused an estimated 73% of tropical and sub-tropical deforestation between 2000 and 2010 (Hosonuma et al., 2012[99]). While conversion of land to agriculture is a longstanding phenomenon across all continents, recent emissions from deforestation and peat land conversion have been caused to an important degree by the expansion of pasture for cattle in Latin America, and by the expansion of oilseeds production (notably palm oil) in Indonesia, as well as other countries in Asia and Latin America (Pendrill et al., 2019[100]). Still, the growth of agricultural output per unit of land has prevented an even worse outcome.

Direct greenhouse gas emissions

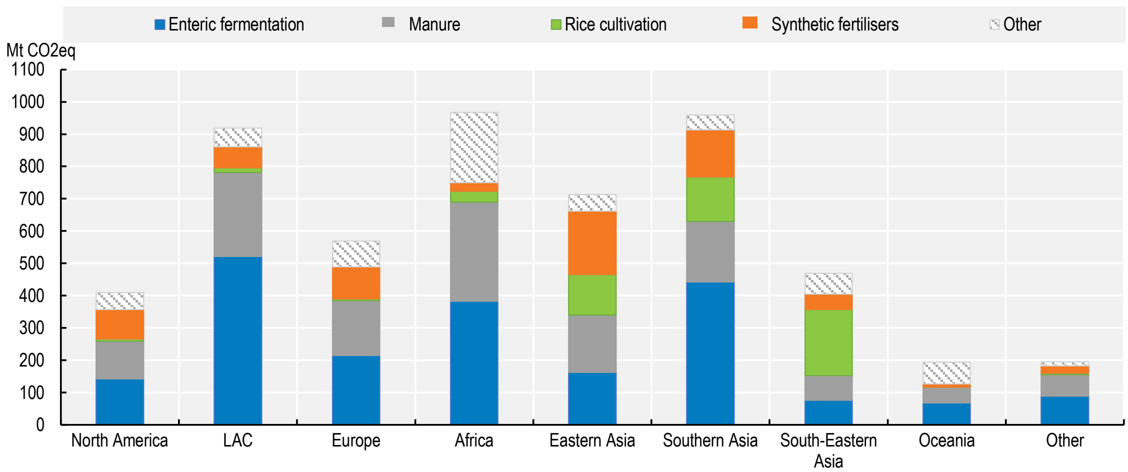
In addition to the important emissions from agricultural land use change mentioned earlier, agricultural production also causes important direct GHG emissions. These emissions account for 12% of global anthropogenic greenhouse gas emissions (IPCC, 2019[85]); agricultural production's share of global anthropogenic emissions is 44% for methane (CH_4) and 82% for nitrous oxide (N_2O).[25]

Two-thirds of the direct emissions from agricultural production are due to livestock. In a process known as "enteric fermentation", cattle and other ruminants such as sheep and goats produce methane as part of their digestive process. This process by itself has accounted for some 40% of direct emissions from agriculture in recent years. Emissions from manure contribute another 26% to direct emissions. Two other important contributors are synthetic fertilisers (responsible for 13% of direct emissions from agriculture) and rice cultivation (accounting for 10% of the total).[26]

Direct emissions from agriculture are not limited to one region or one agricultural production system (Figure 1.9). The sources of emissions tend to vary by region, although livestock-related emissions typically dominate, except in Eastern and South-Eastern Asia.

Between 1990 and 2016, direct emissions from agriculture grew by 0.5% per year. By comparison, global crop production grew by an estimated 2.5% per year over the same period, while livestock production grew an estimated 1.9% per year.[27] Emissions per unit of agricultural output have therefore fallen over time as agricultural productivity has grown, a trend which is true for most regions (Blandford and Hassapoyannes, 2018[96]). The emissions intensity of livestock in particular has fallen considerably since the 1970s (Smith et al., 2014[97]). However, beef continues to have by far the largest emissions footprint per unit of product among the major agricultural commodities (Gerber et al., 2013[101]). Emissions intensities for livestock vary considerably around the world and are highest in regions with low yields of animal agriculture (e.g. low milk yields, low slaughter weights, or a long time until animals are ready for slaughter). The quality of feed in particular is an important driver of productivity (and hence lower emissions intensities) (Herrero et al., 2013[102]).

Figure 1.9. Direct emissions from agriculture, by region and source, 2018



Note: 2018 or latest available. LAC is Latin America and the Caribbean. Manure includes manure applied to soils, manure left on pasture, and manure management. Other includes the FAOSTAT categories Burning - Crop Residues, Burning - Savanna, Crop Residues, and Cultivation of Organic Soils.
Source: FAOSTAT.

Environmental effects of intensification

The strong growth in agricultural output per unit of agricultural land is due in large part to a more intensive use of inputs. Since 1961, global consumption of nitrogen fertilisers grew almost nine-fold, while consumption of phosphorus and potassium fertilisers nearly quadrupled.[28] Over the same period, the share of global cropland under irrigation grew from 12% to 21%, and agricultural water use grew from 1 500 km^3 to 2 800 km^3 per year.[29] Between 1990 and 2015, global pesticide use grew from 2.7 million tonnes of active ingredients to 4 million tonnes.[30] Together with modern varieties and better management practices, the use of these inputs has contributed to unprecedentedly high crop yields, both in developed and developing countries. Intensive input use similarly contributed to growth in livestock production, e.g. through the use of concentrated animal feed.

Yet, this intensification of agricultural production has brought with it new challenges. For instance, the widespread use of synthetic nitrogen fertiliser and the large quantities of manure produced by intensive livestock systems not only contribute to global warming but can also cause severe damage to aquatic ecosystems (OECD, 2018[103]). Nitrogen pollution leads to the acidification of freshwater ecosystems, which harms invertebrates (such as crustaceans) and fish. Nitrogen also causes eutrophication, i.e. the proliferation of phytoplankton and algae. The subsequent decomposition of organic matter of these organisms consumes oxygen, leading to hypoxia (low oxygen levels in the water); one result is extensive deaths of both invertebrates and fish.[31] Eutrophication also directly stimulates the growth of toxic algae (Camargo and Alonso, 2006[104]).

As another example, pesticide use has been associated with declines in populations of wild bees (Brittain et al., 2010[105]) and insectivorous birds (Hallmann et al., 2014[106]) among others, and with harmful effects on broader ecosystem services (Chagnon et al., 2015[107]). A study of several European countries found that insecticides and fungicides had consistent negative effects on biodiversity (Geiger et al., 2010[108]). Exposure to certain pesticides can also have negative effects on human health, including acute toxicity, carcinogenicity, mutagenicity, or reproductive toxicity (WHO, 2010[109]) (Mostafalou and Abdollahi, 2017[110]), although there are currently no reliable estimates of the global health impact of pesticides (WHO, 2019[111]).[32]

Intensive use of inputs thus has had undesirable consequences. However, there are important differences among countries and regions. For example, agriculture accounts for some 70% of global water withdrawals, but agriculture's share is particularly high in South and Southeast Asia, the Middle East, and Africa. In North America and Europe, agriculture's share is smaller (although still sizeable). The impact of this water use also differs strongly. Water stress is particularly high in the Middle East and North Africa, given the low availability of water resources. But even in otherwise water-abundant countries, there could be local hotspots with water scarcity risks (World Resources Institute (2019[112]), OECD (2017[113])). As another example, application rates of synthetic nitrogen are especially high in East Asia (above 170 kg per hectare) and Western and Central Europe (around 150 kg per hectare), but lower in North America (around 73 kg per hectare).[33] Some developing regions (notably Sub-Saharan Africa) have low application rates and struggle with negative nutrient balances, meaning that fertiliser inputs are not sufficient to compensate for removals through harvest. At the same time, nitrogen leaching and runoff in Asia has been estimated at 15 million tonnes per year, or 64% of the global total (Liu et al., 2010[114]).

Over the past two decades, OECD countries have on average experienced declining nitrogen and phosphorus surpluses, despite growing agricultural production, which demonstrates that progress is possible (OECD, 2019[115]). Better policies, coupled with efficiency gains, offer considerable scope to limit or reduce environmental damage from intensive input use.

Poor policy choices often contribute to inefficient input use. In many countries, the use of irrigation water by farmers is insufficiently regulated and farmers do not pay the full price, leading to excessive water use. In the Middle East and North Africa, agricultural policy often stimulates the consumption and production of water-intensive but relatively low value crops such as wheat at the expense of horticultural crops which would generate greater value relative to their use of water (OECD/FAO, 2018[116]). Many countries continue to provide agricultural support through instruments which stimulate production and excessive input use; these instruments have been shown to be not only economically wasteful but also environmentally harmful, as discussed in more detail below.

In addition, evidence suggests that input use in many cases is inefficiently high. At the global level, nitrogen uptake by crops has been estimated at less than 60% of total inputs. Two-fifths of global nitrogen inputs are therefore lost into ecosystems, indicating considerable room for improving the efficiency of nitrogen use (Liu et al., 2010[114]). Data for France shows no clear link between pesticide intensity and productivity or profitability for the majority of farms, which suggests that pesticide use in some cases could be cut with little or no opportunity cost (Lechenet et al., 2017[117]) (Lechenet et al., 2014[118]). Similarly, the use of antimicrobials for growth promoting purposes in some livestock production can, with more sanitary farming practices, be eliminated with little or no adverse impact on the economic or technical performance of farms (Ryan, 2019[119]). These examples suggest both that smart environmental regulations in agriculture do not necessarily come at an economic cost, and that efficiency gains make it possible to increasingly "decouple" agricultural production from its environmental impacts.

Environmental effects of efficiency gains

In addition to land expansion and greater use of fertilisers, pesticides, and animal feed, other factors such as better management practices and better technology have played an important role in raising agricultural output and productivity both in the developing and the developed world. For example, modern crop varieties introduced during the Green Revolution accounted for 40% of crop production growth in developing countries between 1981 and 2000 (Evenson and Gollin, 2003[120]) while the development of better varieties through plant breeding is estimated to account for 59-79% of the seven-fold increase in US maize yields between 1930 and 2011 (Smith et al., 2014[121]).

Better genetics, better management practices and better technology can enable agricultural output growth without a corresponding increase in inputs. Data for the United States show how, relative to dairy practices in 1944, modern dairy practices make it possible to produce milk using only 21% of the number of animals, 23% of the feed, 35% of the water, 10% of the land, 24% of the manure output, 43% of the methane emissions, and 56% of the nitrous oxide emissions; the overall carbon footprint per kg of milk in 2007 was only 37% of that produced in 1944 (Capper, Cady and Bauman, 2009[122]), with further improvements between 2007 and 2017 (Capper and Cady, 2020[123]). Denmark and the Netherlands have reduced their use of synthetic nitrogen fertiliser since the 1980s, while agricultural output has been steadily expanding (OECD, 2019[115]). In the United States, nitrogen use per hectare of maize has been flat or declining over the same period, while maize yields have grown from around 6 tonnes per hectare in the early 1980s to more than 10 tonnes per hectare today.[34]

As these examples suggest, there is scope for efficiency gains which would allow production of the same agricultural output with less inputs, or a greater output with a less than proportional increase in inputs. Technological progress, better management practices and other increases in efficiency are also increasingly important drivers of global agricultural output growth. Continued investments in agricultural innovation are therefore key to achieve more productive, sustainable, and resilient food systems (OECD, 2019[7]).

Policies to limit or reorient demand growth hold the potential to improve the environmental footprint of food systems while meeting objectives of food security and nutrition, as discussed earlier. Such policies could thus also be seen as contributing to efficiency more broadly defined.

Alternative approaches to improving the environmental sustainability of the food system

In response to the environmental toll of intensive agriculture, alternative approaches have gained popularity, emphasising organic, local, and/or small-scale production. By reducing or eliminating the reliance on synthetic inputs (fertilisers and crop protection chemicals) or shortening supply chains, such approaches try to reduce the environmental impact of agricultural production. While some of the proposed practices can indeed help make agriculture more sustainable, alternative approaches have their own shortcomings and are not a panacea (OECD, 2016[124]).

The evidence suggests that organic agriculture achieves better environmental impacts *per unit of land used* (Seufert and Ramankutty, 2017[125]). These alternative approaches face a significant challenge, however, given the robust finding in the literature that organic farming produces considerably less food per unit of agricultural land. Meta-analyses summarising a wide range of comparisons concluded that organic yields are overall 19%-25% lower than yields in "conventional" agriculture, although yield gaps may vary depending on the specific crop and on management practices (de Ponti et al., (2012[126]); Seufert et al., (2012[127]); Ponisio et al. (2015[128])). All else being equal, a yield gap of 20% would imply that 25% more land is needed to produce the same output, which is problematic given the important negative consequences of expanding agricultural land use.[35] Because of this yield gap, organic agriculture requires more land, causes more eutrophication, uses less energy, and causes similar greenhouse gas emissions as conventional systems per unit of food (Clark and Tilman, 2017[129]).

Similarly, local agriculture does not in general minimise environmental impacts (Edwards-Jones et al., 2008[130]). The overwhelming majority of GHG emissions related to food occur through agricultural production and land-use change; all other stages of the food chain (including inputs, energy, processing, transport, etc.) account for only one-fourth of the total (IPCC, 2019[85]). Focusing on transport-related emissions or "food miles" without regard to how the food was produced will thus give a misleading picture. The environmental sustainability of food production differs strongly by region and by food product; depending on circumstances, locally-produced food may be more or less sustainable than imported alternatives, even after taking into account transport.

The environmental footprint of food systems is complex and multifaceted, and often depends on local circumstances. In turn, this means that no single approach will solve the environmental problems of the food system. This is true for alternative approaches such as organic or local agriculture, but it is equally true for a strategy of maximising yields through conventional agriculture in order to save land. In addition to the obvious risk that further intensification of agricultural production to achieve higher yields will exacerbate problems, such as nitrogen runoff or excessive use of pesticides, higher yields – even when due to efficiency gains instead of intensification – do not by themselves protect forests and other valuable areas from expanding agricultural land use.

While higher yields were "land saving" during the Green Revolution in Asia, Latin America, and the Middle East, simulations show that growth in agricultural productivity in Sub-Saharan Africa could increase the profitability of farming in the region and could thus lead to an expansion of production on the continent and reduced production in other regions (Hertel, Ramankutty and Baldos, 2014[131]). As yields in Sub-Saharan Africa would still be lower than in those other regions, the net result may well be an increase in global agricultural land use and GHG emissions, at least in the short run.[36] There is a need to spare land from agricultural expansion, but higher yields do not automatically lead to reduced agricultural land use. Other policies such as explicit conservation measures are needed.

The relative benefits of "land sharing" practices (e.g. adopting wildlife-friendly practices to increase on-farm biodiversity) as opposed to "land sparing" ones (e.g. aiming for high yields to reduce overall agricultural land use) are thus complex (Green et al., 2005[132]). A pragmatic approach is to assess which agricultural practices (e.g. crop rotations, biological pest control, cover crops) are beneficial under which circumstances, and with what trade-offs. This could imply specific roles for conservation agriculture, agro-ecological approaches, agricultural biotechnology and precision agriculture, among other farm management practices (OECD, 2016[124]). None of these constitute a "silver bullet" in terms of environmental sustainability of agriculture, but careful, context-dependent and evidence-based evaluation of specific practices and technologies could hold great potential. Examples of such pragmatic approaches include Integrated Pest Management (Ehler, 2006[133]) and Integrated Soil Fertility Management (Place et al., 2003[134]).[37]

Another shortcoming of the binary classification of "conventional" and "alternative" agricultural approaches is that it ignores the important potential of policies to improve environmental outcomes. Smart policies can make a difference for the environmental sustainability of agriculture.

The role of policies

Policy makers have looked at ways of containing the adverse environmental effects of agricultural production. For instance, with increased scientific understanding, regulatory procedures for pesticides have become more stringent and many harmful pesticides have been banned. Out of the ten best-selling pesticides in the United States in 1968, six are now banned, including DDT (Phillips McDougall, 2018[135]).

Similarly, several countries have taken steps to reduce problems related to fertiliser use. For instance, since the early 1990s, Denmark has reduced its nitrogen balance by 56% and its phosphorus balance by 58%, although its agricultural production has continued to increase over this period. Policy makers used a mix of instruments, including targets for reductions of nitrogen and phosphorus discharges, fertiliser accounting systems, nitrogen quota systems to regulate the use of fertilisers, bans on manure application on bare fields, fertiliser taxes for non-agricultural uses, taxes on phosphorus content in feed, as well as agri-environmental schemes and advisory services (OECD, 2019[115]).

Despite some success stories, however, policies have mostly failed to achieve significant improvements in environmental outcomes. An important factor is that many existing agricultural support policies exacerbate the environmental impact of agriculture. Coupled support measures such as import tariffs or output and input subsidies encourage farmers to expand production, to use more fertiliser and other inputs, and/or to expand agricultural land use, and hence have negative environmental impacts. By contrast, relatively less coupled payments, such as those based on historical entitlements, do not encourage intensification or an expansion of agricultural land use and are therefore less harmful to the environment

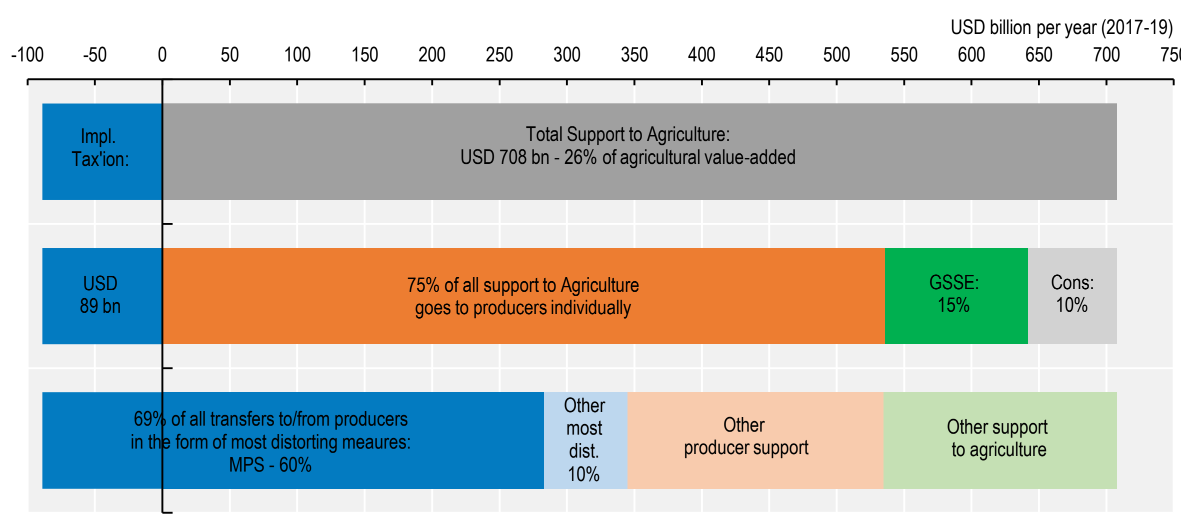
(OECD, 2019[17]) (Henderson and Lankoski, 2019[136]). Less coupled payments can still have indirect effects, however; for instance by keeping farmers in business who would otherwise have left the sector or maintaining production on marginal land. Nevertheless, less coupled payments are in general among the least environmentally harmful support policies. In addition to these environmental effects, less coupled forms of support are economically less distorting than coupled support.

As mentioned earlier, across the 54 OECD and non-OECD economies covered in the OECD's *Agricultural Policy Monitoring and Evaluation*, the agricultural sector receives USD 708 billion per year in support, of which USD 536 billion per year is support to individual producers through various support measures, including through higher prices paid by consumers Figure 1.10) (OECD, 2019[137]) (OECD, 2020[81]). Market price support and other coupled support account for much of the total; agricultural policy thus still relies to an important extent on the most distortionary and potentially most environmentally harmful instruments.[38] Market price support is measured as the policy-induced gap between domestic and border prices, and constitutes a transfer of resources from consumers to producers. Direct payments, on the other hand, are taxpayer financed, which means they can potentially be reallocated to other uses.

Based on the current profile of agricultural support policies around the world, a move to less coupled forms of support would likely reduce the environmental pressures from agriculture. Even with less coupled support, however, market price signals will typically not take into account environmental externalities associated with agricultural production. Decoupling on its own is therefore unlikely to fully resolve the environmental problems related to agriculture. Other policy instruments, such as environmental regulations or agri-environmental payments, are needed to tackle the negative environmental externalities of the food system.

Environmental regulations can play an important role in the policy mix. Existing studies show that the negative economic impact of such regulations is not necessarily as high as is often believed; some studies even appear to show a positive effect on economic efficiency.[39] As discussed earlier, evidence shows that agricultural inputs such as fertilisers are often used at inefficiently high levels. Regulations to reduce these levels can in such circumstances improve efficiency and environmental performance.

Figure 1.10. Support to agriculture, 2017-19



Note: "Impl. Tax'ion" is implicit taxation of producers, "GSSE" is General Services Support Estimate, "Cons" is the Consumer Support Estimate, "Other most dist." refers to the most distorting producer support measures other than market price support.
Source: Based on OECD (2020), *Agricultural Policy Monitoring and Evaluation 2020*.

On the other hand, the evidence regarding the effectiveness of agri-environmental schemes suggests considerable room for improvement. The objectives of such policies are sometimes ill-defined or may not be sufficiently ambitious. A lack of detailed scientific data may also make it difficult to develop effective policies. This problem is compounded by the heterogeneity of agricultural landscapes and production practices. As many policies focus on encouraging or discouraging specific practices, rather than focusing on environmental outcomes, there is a risk that policies will stimulate ineffective practices. An outcome-based approach with careful measurement and evaluation, and taking into account differing environmental conditions, is probably more effective. Finally, an overarching challenge in designing effective policies is that evidence about the environmental impacts is often lacking, making it difficult to judge the cost-effectiveness of policies.

Despite these shortcomings, agri-environmental policies have an important role to play in improving the environmental footprint of agriculture. However, an improved evidence base and a careful choice of policy instruments and their design features will be necessary to increase their impact.

Another possible lever for public policies to improve environmental sustainability is to stimulate improved transparency and traceability along the food chain. By making it easier for consumers to identify sustainably-produced items, governments may create incentives for producers to adopt sustainable practices and may point consumers towards a diet with a more favourable environmental footprint. Many environmental labelling and information schemes (ELIS) exist: one analysis found that more than 500 such schemes were introduced around the world between 1970 and 2012, across all sectors (Gruère, 2013[138]). Most of these schemes are voluntary, and are either initiated by a non-profit or by the private sector. One challenge in the use of such voluntary schemes is to avoid misleading or fraudulent claims. The private sector can increase the credibility of a voluntary scheme by third-party certification, but public policies can also help. Countries differ in how environmental claims are regulated, but in many countries misleading claims can be challenged under consumer protection laws (Klintman, 2016[139]). A range of other possibilities exist for public policies: e.g. mandating the disclosure of certain information; harmonising existing voluntary standards; stimulating the creation of new standards; overseeing certification; or creating a public standard (Rousset et al., 2015[140]). Developments in digital technology could open up new possibilities for increased traceability and transparency along supply chains, in addition to the opportunities they offer to improve agricultural policies through better data collection, processing and sharing (Baragwanath, 2021[50]) (OECD, 2019[13]).

These policy levers are focused on providing better market signals. Yet the importance of efficiency gains for sustainability also points to a more direct role for public policies to facilitate the uptake of more efficient and more sustainable practices and technologies, as well as to stimulate innovation. Both public and private efforts need to be strengthened, which requires public funding for food and agricultural research, and public-private partnerships (OECD, 2019[7]).

1.5. Conclusion

Across the dimensions of the triple challenge – ensuring food security and nutrition for all, providing livelihoods to farmers and others along the food chain, and using natural resources sustainably while reducing greenhouse gas emissions – food systems are sometimes accused of “systems failure”. As the summary assessment in this chapter shows, such claims overlook important achievements across all three dimensions, although important challenges exist and require urgent attention. Policies have not managed to keep up with rapid structural change across food systems and the problems these changes have induced, be they a rising incidence of obesity, continued adjustment pressures on farmers, or mounting GHG emissions.

Much is known about how policies can be reformed to achieve better outcomes. Existing agricultural support policies often exacerbate problems, and removing counterproductive measures would have important benefits. However, additional pro-active policy efforts are needed to effectively address the various components of the triple challenge in order to effectively contribute to the Sustainable Development Goals. While the complexity of food systems makes it impossible to provide an exhaustive overview, this chapter has highlighted that the existing wide range of analysis (by the OECD and others) can inform such efforts.

One contribution of a food systems perspective is to bring that analysis under a single organising framework in order to obtain a sense of relative policy priorities. The real value of a food systems perspective, however, is to highlight the synergies and trade-offs between policy domains which have historically often been treated in isolation. Some of these interactions are domestic, while others spill across international borders. An awareness of such interactions has several implications for policy makers. Any suggested policy could affect other dimensions of the triple challenge, so policy proposals need to be assessed with the possibility of such spill-overs in mind. Interactions could also offer new levers to address problems by exploiting synergies or adjusting policies with unwanted negative spill-over effects. All of this requires co-ordination between different policy-making communities. Some policy choices may simply be domestic matters, while others may need to be co-ordinated internationally, as one country's choices may affect the balance of synergies and trade-offs for other countries' choices. Chapter 2 develops these principles for policy coherence in more detail.

As the discussion in this chapter has shown, there are wide gaps between policies that the evidence suggests would be effective in addressing the triple challenge, and the policies that are currently adopted in many countries. Those gaps may arise due to difficulties in identifying and addressing synergies and trade-offs, but may also reflect issues such as disagreements over facts (e.g. a gap between popular beliefs and scientific evidence), diverging interests, or differences over values. As discussed in Chapter 3, policy-making processes should be designed to generate trusted evidence, to limit the influence of special interests, and to mediate between different values. Strong political leadership is needed to achieve policies which are coherent both domestically and internationally, and which are sufficiently ambitious to meet the triple challenge.

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Notes

[1] The challenges for food systems are a crucial aspect of the broader challenges facing humanity as a whole. Of the 17 UN Sustainable Development Goals (SDGs), nearly all link either directly or indirectly to food systems. Food security is linked to SDG2 (zero hunger) and SDG3 (good health and well-being). Livelihoods and rural development are reflected in SDG1 (no poverty), SDG6 (decent work and economic growth), and SDG10 (reduced inequalities). Sustainable resource use and climate change mitigation are contained within SDG12 (responsible consumption and production), SDG13 (climate action), SDG14 (life below water) and SDG15 (life on land). Other SDGs are important to the attainment of challenges facing food systems, including SDGs pertaining to education, institutions and gender equality. In the remainder of this report, the term "sustainability" is used to mean "environmental sustainability" unless explicitly indicated.

[2] Numbers based on FAO's Net Agricultural Production Index (1960-2010) from FAOSTAT.

[3] An estimated 1.9 billion people were moderately or severely food insecure in 2017-19 (FAO, 2020[26]). The World Health Organization estimates that more than 1.9 billion adults and more than 340 million children and adolescents were overweight or obese in 2016; see https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.

[4] Agricultural production, land use and yield data from FAOSTAT (see Section 1.4); GHG emissions data from (IPCC, 2019[85]).

[5] Country policy responses to COVID-19 are discussed in *OECD Agricultural Policy Monitoring and Evaluation 2020*, while the medium-term impact on markets and trade is discussed in the *OECD-FAO Agricultural Outlook 2020-2029*. Information on supply conditions of major agricultural crops and on policy developments is available through the Agricultural Market Information System (AMIS) at www.amis-outlook.org. For a discussion of broader policy implications of COVID-19, see www.oecd.org/coronavirus/en/.

[6] For this reason, in some contexts it makes sense to talk about "the global food system" (singular) when emphasising, for example, global environmental challenges related to food and agriculture, or the importance of international trade in agri-food products. In line with common usage, this chapter mostly uses the term "food systems" (plural) to emphasise the heterogeneity and diversity of food production and consumption around the world, and to highlight the importance of taking into account this local context in designing effective policies. This, of course, does not diminish the importance of the global dimension, as food systems do not exist in isolation from each other or from global processes.

[7] This section builds on and updates material contained in OECD (2013[6]).

[8] An example of such efforts is the Global Research Alliance (www.globalresearchalliance.org), launched in December 2009, which focuses on research, development and extension of technologies and practices to create more productive and climate-resilient food systems without growing greenhouse gas emissions.

[9] The share of calorie intake coming from ultra-processed foods has been estimated at 30% in Mexico (Marrón-Ponce et al., 2018[184]), 35% in France (Julia et al., 2018[183]), 38% in Japan (Koiwai et al., 2019[182]), 48% in Canada (Moubarac et al., 2017[179]), 57% in the United Kingdom (Rauber et al., 2018[181]), and 59% in the United States (Baraldi et al., 2018[180]).

[10] These recommendations are based in part on studies suggesting that excessive consumption of processed and/or red meat is associated with higher risks of cardiovascular disease, stroke, various forms of cancer, as well as with overall mortality (Abete et al., 2014[166]) (Chen et al., 2013[167]) (Pan et al., 2012[168]) (Sinha et al., 2009[169]) (Etemadi et al., 2017[170]). A set of recent papers has argued that these effects may be overstated due to various methodological difficulties (Zeraatkar et al., 2019[171]) (Zeraatkar et al., 2019[172]) (Vernooij et al., 2019[173]) (Han et al., 2019[174]).

Although these reviews also tend to find an association between red and/or processed meat intake and various adverse health outcomes, the authors argue that the effects are small and that the underlying evidence is weak.

[11] This four-track approach for healthier food choices could easily be adapted to encourage more sustainable choices.

[12] A related approach focuses on food fortification and biofortification (the use of plant breeding to increase the micronutrient content of crops) to combat micronutrient deficiencies, especially in the developing world (Allen et al., 2006[185]) (Nestel et al., 2006[186]).

[13] See the UK Code of Broadcast Advertising (Art. 13.9-13.15) and the UK Code of Non-broadcast Advertising and Direct & Promotional Marketing (Section 15), available at www.asa.org.uk.

[14] At least 12 OECD countries have implemented federal health-related taxes, most commonly on soft drinks or sugar-sweetened beverages (Giner and Brooks, 2019[49]).

[15] See www.amis-outlook.org.

[16] Internationally, there has been a shift from food aid to food assistance (Cardwell, 2008[162]). Local procurement of food (e.g. within a given region) can reduce costs and improve timeliness. Better targeting of the needy can also reduce local market disincentives (depression of prices for farmers).

[17] For a discussion of the agricultural transformation, see OECD (2012[79]). Barrett et al. (2017[158]), and Jayne et al. (2018[159]) discuss recent experiences and prospects for transformation in Africa.

[18] The share of manufacturing in employment first peaks and then declines as countries develop, with productivity and income growth stimulating the growth of demand for manufactures. But there is evidence of the peak share becoming lower, and occurring at an earlier stage of income development (Rodrik, 2016[157]; Lawrence, 2017[189]). In some countries trade is a reason, but the common global factor is relatively rapid technological diffusion in manufacturing.

[19] See Greenville et al. (2019[74]) for a detailed discussion on services used to create value-added in agro-food exports.

[20] See https://www.ers.usda.gov/data-products/food-dollar-series/documentation/ (accessed 21 October 2020).

[21] Several reviews of the literature have concluded there is currently no evidence for large, systematic deviations from competitive conditions in food chains, although specific problems may exist in some markets, as is true for any economic sector (Sheldon, (2017[150]), Saitone and Sexton (2017[151]), McCorriston (2014[152]), Perekhozhuk et al. (2017[153]), Dillon and Dambro (2017[156])). Competition authorities can take a pro-active attitude to monitoring competition in the food chain, for instance by using their investigative powers to conduct market studies (OECD, 2018[155]). Policy makers can also play an important role in safeguarding competition by screening existing and proposed regulations for their potential anti-competitive effects (OECD, 2016[154]).

[22] A large literature has explored income and welfare effects of farmer participation in modern value chains, e.g. through participation in contract farming. While many studies find positive effects (Swinnen, 2007[176]), impacts appear to be context-dependent (Meemken and Bellemare, 2020[175]). Agricultural certification schemes (e.g. Fairtrade) similarly appear to have mixed effects (Oya, Schaefer and Skalidou, 2018[177]) (Meemken et al., 2019[178]).

[23] IPCC (2019[85]) estimates emissions from land-use changes related to food systems globally at 4.9 ± 2.5 Gigatonnes of CO_2-equivalent (Gt CO_2e) per year, with 6.2 ± 1.4 Gt CO_2e per year coming from direct agricultural emissions.

[24] Agricultural land use is not uniformly bad for the environment. In some regions, for instance, the revegetation of extensively grazed pastures could lead to the growth of woody bushes which increase the risk of wildfires (Collins

et al., 2015[163]). Still, there is little doubt that at the global level agricultural land expansion has on balance had negative environmental consequences.

[25] In addition to contributing to climate change, agriculture is one of the sectors most affected by it (FAO, 2016[164]) (Nelson et al., 2014[165]). It thus faces the double challenge of mitigation and adaptation.

[26] Emissions data cited in this paragraph are from FAOSTAT and refer to 2016.

[27] These growth rates refer to the compound annual growth rate between 1990 and 2014 in FAO's Net Production Index Number for crops and livestock, respectively.

[28] Data from the International Fertilizers Association's IFASTAT database (www.ifastat.org).

[29] Data on irrigated cropland as a share of the total from FAOSTAT. For estimates of water withdrawal and water consumption during the 20th century up to 1995, see Shiklomanov (2000[144]), who also forecast agricultural water withdrawal of 2 817 km^3 by 2010, which is nearly identical to the 2 833 km^3 suggested by the most recent FAO Aquastat data. (This figure is based on the most recently available data for each country; the average reporting year, weighted by agricultural withdrawal volume, is 2012).

[30] Data from FAOSTAT.

[31] A well-known example is the flow of excess nitrogen from the US Midwest contributing to a "dead zone" in the Gulf of Mexico (Goolsby et al., 2000[145]).

[32] A detailed analysis by Fantke et al. (2012[146]) has tried to quantify the total health impact and cost of pesticide use in Europe based on 133 pesticides applied in 24 European countries in 2003 which account for almost half of total pesticide use in that year. For these pesticides, the study estimated that annually some 2 000 disability-adjusted life years (DALYs) are lost due to pesticides, corresponding to a monetary cost of EUR 78 million. At the global level, one of the main channels through which pesticides affect human lives is by facilitating suicide; pesticide self-poisoning is one of the most commonly used methods of suicide worldwide, with an estimated 260 000 death annually, around one-third of all suicides (Gunnell et al., 2007[147]).

[33] Fertiliser consumption statistics from the International Fertilizer Association (www.ifastat.org); crop land data from FAOSTAT.

[34] Fertiliser data from United States Department of Agriculture (2019), "Fertilizer Use and Price", https://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx ; maize yields from FAOSTAT.

[35] In response to such arguments, proponents have argued that organic agriculture could feed the world without extra land use if coupled with reductions in food waste and reduced consumption of meat (thereby freeing up land now used for feed production) (Muller et al., 2017[149]). However, the same demand reduction measures would arguably result in even lower agricultural land use when combined with higher-yielding conventional agriculture, potentially freeing up land for afforestation.

[36] Recent research (Villoria, 2019[160]) shows that productivity growth between 1991 and 2010 had a negligible effect on land use in most countries, led to increased land expansion in major commodity exporting countries, and was land-saving only in a small number of countries which are relatively closed to international trade. At the global level, however, productivity growth was land-saving, as production was re-allocated internationally to more productive countries. Results show that a simultaneous 1% increase in agricultural total factor productivity in each country would reduce global cropland demand by 0.34%. A follow-up paper (Villoria, 2019[161]) showed that in the absence of productivity growth, 125 million hectares of additional agricultural land would have been needed in the decade from 2001-2010, which would have resulted in emissions of 17 to 84 gigatonnes of CO_2 equivalent (depending on where

the expansion would have taken place), in contrast with the 1 to 15 gigatonnes of CO_2 equivalent from observed land use change.

[37] An additional benefit of this pragmatic approach is that it avoids creating polarised attitudes to food and agriculture by seemingly forcing a choice between one of two competing systems or worldviews (Mehrabi, Seufert and Ramankutty, 2017[148]).

[38]Some countries also tax their agricultural producers using measures that depress domestic prices. These implicit taxes amount to USD 89 billion. The net transfer to agricultural producers is therefore USD 447 billion per year. These implicit taxes also create market distortions.

[39] See OECD (2021) “Exploring the Linkages between Policies, Productivity and Environmental Sustainability”, OECD Publishing, Paris forthcoming (COM/TAD/CA/ENV/EPOC(2019)4/FINAL).

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