Food and Agriculture Organization of the United Nations

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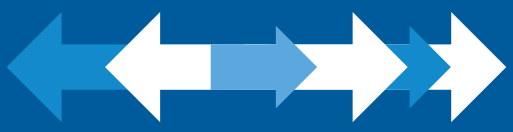
The future of food and agriculture

Trends and challenges



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Foreword

FAO's vision is of a 'world free from hunger and malnutrition, where food and agriculture contribute to improving the living standards of all, especially the poorest, in an economically, socially and environmentally sustainable manner'. To help its Member Countries realize that shared vision – individually at the national level and collectively at the regional and global levels – FAO organizes its work taking account of the main challenges facing the food and agriculture sector. The present study, which was undertaken for the quadrennial review of FAO's Strategic Framework and preparation of the Organization's Medium-Term Plan, 2018–21, lays out key global trends and challenges that will influence food and agriculture in the coming decades.

The trends and challenges analysed here are cause for both hope and concern. Much progress has been made in reducing hunger and poverty and improving food security and nutrition. Gains in productivity and technological advances have contributed to more efficient resource use and improved food safety. But major concerns persist. Some 795 million people still suffer from hunger, and more than two billion from micronutrient deficiencies or forms of overnourishment. In addition, global food security could be in jeopardy, due to mounting pressures on natural resources and to climate change, both of which threaten the sustainability of food systems at large. Planetary boundaries may well be surpassed, if current trends continue.

Our assessment of prevailing trends suggests, therefore, that in order to realize FAO's vision, transformative change in agriculture and food systems are required worldwide. In FAO's view, there are 10 key challenges that need to be addressed if we are to succeed in eradicating hunger and poverty, while making agriculture and food systems sustainable. Those challenges include the uneven demographic expansion that will take place in the coming decades, the threats posed by climate change, the intensification of natural disasters and upsurges in transboundary pests and diseases, and the need to adjust to major changes taking place in global food systems.

We welcome the growing attention that the international community is paying to these concerns. Overall trends and issues have spurred the global community to action through a series of initiatives and agreements in 2015–16, which have reset the global development agenda. These developments constitute the global context for FAO's work in the future, under the overall umbrella of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs), and include the Addis Ababa Action Agenda, the Paris Agreement on climate change, the World Humanitarian Summit and the United Nations Secretary-General's Agenda for Humanity.

The purpose of this report is to help mobilize the concrete and concerted actions required to realize these global agendas. It contributes to a common understanding of the major long-term trends and challenges that will determine the future of food security and nutrition, rural poverty, the efficiency of food systems, and the sustainability and resilience of rural livelihoods, agricultural systems and their natural resource base.

José Graziano da Silva
Director-General
Food and Agriculture Organization
of the United Nations

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Preparation of both the preliminary study and this publication was coordinated by FAO's Global Perspective Studies (GPS) team in the Economics and Social Development (ES) Department, under the general direction and oversight of Rob Vos, Director of FAO's Agricultural Development Economics Division (ESA). Lorenzo Giovanni Bellù (GPS Team Leader) coordinated the technical work. Kostas Stamoulis, Assistant Director-General a.i. of ES Department, and Boyd Haight, Director of the Office of Resources and Strategic Planning (OSP), provided general guidance and encouragement to complete the work. Aysen Tanyeri-Abur (OSP) provided substantive inputs to the study while Martin Piñeiro (OSP) contributed to the study design and overall orientation.

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Abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
AMR	antimicrobial resistance
AT2050	*World agriculture towards 2030/2050: the 2012 revision* (Alexandratos and Bruinsma, 2012)
DES	dietary energy supply
DRR	disaster risk reduction
FAO	Food and Agriculture Organization of the United Nations
FBS	food balance sheets
FDI	foreign direct investment
FMD	foot-and-mouth disease
GDP	gross domestic product
GHG	greenhouse gas
GMO	genetically modified organism
Gt	gigatonne
ha	hectare
IFAD	International Fund for Agricultural Development
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
LOESS	local polynomial regression
MDG	Millennium Development Goal
NDC	Nationally Determined Contribution
NGO	non-governmental organization
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OECD-DAC	OECD Development Assistance Committee
OIE	World Organisation for Animal Health
PPP	purchasing power parity
R&D	research and development
RFPI	real food price index
RTA	regional trade agreement
SDG	Sustainable Development Goal
SSP	Shared Socioeconomic Pathway
TFP	total factor productivity
TTIP	Transatlantic Trade and Investment Partnership
TTP	Trans-Pacific Partnership
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WFP	World Food Programme
WHO	World Health Organization

Executive summary

The future of food and agriculture

TRENDS

A number of global trends are influencing food security, poverty and the overall sustainability of food and agricultural systems.

The world's population is expected to grow to almost 10 billion by 2050, boosting agricultural demand – in a scenario of modest economic growth – by some 50 percent compared to 2013. Income growth in low- and middle-income countries would hasten a dietary transition towards higher consumption of meat, fruits and vegetables, relative to that of cereals, requiring commensurate shifts in output and adding pressure on natural resources.

Economic growth and population dynamics are driving the structural change of economies.

The decline in the share of agriculture in total production and employment is taking place at different speeds and poses different challenges across regions. Although agricultural investments and technological innovations are boosting productivity, growth of yields has slowed to rates that are too low for comfort. Food losses and waste claim a significant proportion of agricultural output, and reducing them would lessen the need for production increases. However, the needed acceleration in productivity growth is hampered by the degradation of natural resources, the loss of biodiversity, and the spread of transboundary pests and diseases of plants and animals, some of which are becoming resistant to antimicrobials.

Climate change affects disproportionately food-insecure regions, jeopardizing crop and livestock production, fish stocks and fisheries.

Satisfying increased demands on agriculture with existing farming practices is likely to lead to more intense competition for natural resources, increased greenhouse gas emissions, and further deforestation and land degradation.

Hunger and extreme poverty have been reduced globally since the 1990s.

Yet, around 700 million people, most of them living in rural areas, are still extremely poor today. In addition, despite undeniable progress in reducing rates of undernourishment and improving levels of nutrition and health, almost 800 million people are chronically hungry and 2 billion suffer micronutrient deficiencies. Under a 'business-as-usual' scenario, without additional efforts to promote pro-poor development, some 653 million people would still be undernourished in 2030. Even where poverty has been reduced, pervasive inequalities remain, hindering poverty eradication.

Critical parts of food systems are becoming more capital-intensive, vertically integrated and concentrated in fewer hands.

This is happening from input provisioning to food distribution. Small-scale producers and landless households are the first to lose out and increasingly seek employment opportunities outside of agriculture. This is driving increased migratory flows, especially of male members of rural households, which is leading, in turn, to the 'feminization' of farming in many parts of the world.

Conflicts, crises and natural disasters are increasing in number and intensity.

They reduce food availability, disrupt access to food and health care, and undermine social protection systems, pushing many affected people back into poverty and hunger, fuelling distress migration and increasing the need for humanitarian aid. Violent conflict also frequently characterizes protracted crises. On average, the proportion of undernourished people living in low-income countries with a protracted crisis is between 2.5 and 3 times higher than in other low-income countries.

CHALLENGES

These trends pose a series of challenges to food and agriculture.

High-input, resource-intensive farming systems, which have caused massive deforestation, water scarcities, soil depletion and high levels of greenhouse gas emissions, cannot deliver sustainable food and agricultural production. Needed are innovative systems that protect and enhance the natural resource base, while increasing productivity. Needed is a transformative process towards 'holistic' approaches, such as agroecology, agro-forestry, climate-smart agriculture and conservation agriculture, which also build upon indigenous and traditional knowledge. Technological improvements, along with drastic cuts in economy-wide and agricultural fossil fuel use, would help address climate change and the intensification of natural hazards, which affect all ecosystems and every aspect of human life. Greater international collaboration is needed to prevent emerging transboundary agriculture and food system threats, such as pests and diseases.

Eradicating extreme poverty, and ensuring that vulnerable people who escape poverty do not fall back into it, requires action to reduce inequalities.

That means addressing inequalities both between and within countries, in levels of income, in opportunities and in ownership of assets, including land. Pro-poor growth strategies, which ensure that the weakest participate in the benefits of market integration and investment in agriculture, would improve their income and investment opportunities in rural areas and address the root causes of migration.

But pro-poor growth must go beyond agriculture, by involving both rural and urban areas and supporting job creation and income diversification.

Social protection combined with pro-poor growth will help meet the challenge of ending hunger and addressing the triple burden of malnutrition through healthier diets. Permanently eliminating hunger, malnutrition and extreme poverty also requires building resilience to protracted crises, disasters and conflicts, and preventing conflicts by promoting inclusive and equitable global development.

A rethinking of food systems and governance is essential for meeting current and future challenges.

Vertically coordinated, more organized food systems offer standardized food for urban areas and formal employment opportunities. But they need to be accompanied by responsible investments and concern for smallholder livelihoods, the environmental footprint of lengthening food supply chains, and impacts on biodiversity. These concerns need to be addressed by making food systems more efficient, inclusive and resilient.

On the path to sustainable development, all countries are interdependent.

One of the greatest challenges is achieving coherent, effective national and international governance, with clear development objectives and commitment to achieving them. The 2030 Agenda for Sustainable Development embodies such a vision – one that goes beyond the divide of 'developed' and 'developing' countries. Sustainable development is a universal challenge and the collective responsibility for all countries, requiring fundamental changes in the way all societies produce and consume.

Cause for hope and concern

Global trends and challenges that are shaping our future

Over the past century, enormous progress has been achieved worldwide in improving human welfare. Societies have changed radically thanks to quantum leaps in technology, rapid urbanization, and innovations in production systems. Yet conditions in today's world are a far cry from the world 'free of fear and want' envisioned at the foundation of the United Nations. Similarly, much remains to be done to fulfil the vision of the Food and Agriculture Organization of the United Nations (FAO): to create 'a world free of hunger and malnutrition and one in which food and agriculture contribute to improving the living standards of all, especially the poorest, in an economically, socially and environmentally sustainable manner'.

Amid great plenty, billions of people still face pervasive poverty, gross inequalities, joblessness, environmental degradation, disease and deprivation. Displacement and migratory flows are at their highest levels since the Second World War. Many armed conflicts have been resolved, but new ones have emerged. Much of humanity's progress has come at a considerable cost to the environment. The impacts of climate change are already being felt, and – if left unabated – will intensify considerably in the years ahead. Globally integrated production processes have brought many benefits, but present challenges in terms of their regulation and the need to steer them towards more equitable and sustainable outcomes.

Population dynamics will radically change demographics over the coming decades and towards the end of the century. Projected growth in the world's population is expected to be concentrated in Africa and South Asia and in the world's cities. By mid-century, two-thirds of the global population will live in urban areas. Low-income countries will see large increments in the 15-24 years age group. The population will continue to grow in South Asia until mid-century, and in sub-Saharan Africa until at least the end of the century. By the year 2100, Asia and Africa are expected be home to a combined population of 9 billion, out of the projected 11 billion people who will inhabit Earth.

Population growth could provide these regions with a huge demographic dividend and massive growth in domestic markets. However, cashing in on this dividend will be challenging. Unless adequate economic opportunities are created, the boon may well turn out to be a bane, one that fuels mass migration and, possibly, conflicts. Other regions, meanwhile, will have to adjust to rapidly ageing populations.

The changing demographics will further increase the weight of low- and middle-income countries in the global economy. However, this does not necessarily mean incomes will converge among nations and individuals. In recent decades, rapid growth in emerging economies has contributed to some decline in levels of inequality among countries. But this has been offset, by and large, by rising inequality *within* most countries, whatever their income level. Despite significant economic growth since 2000, the average income of people living in Africa is about 5 percent of the average income of citizens living in the United States. This proportion is less than what it was half a century ago. This reveals not only deep imbalances in current levels of well-being but also the huge disparities in the capacity to save and invest in future income generation. While the full implications of this situation for future trends are hard to predict, it is likely that vast global inequalities will persist for some time to come, even if low-income countries do manage to benefit from their demographic dividend.

Agriculture and food systems have already changed significantly, but will need to adjust further in this evolving global environment

Agricultural production more than tripled between 1960 and 2015, owing in part to productivity-enhancing Green Revolution technologies and a significant expansion in the use of land, water and other natural resources for agricultural purposes. The same period witnessed a remarkable process of industrialization and globalization of food and agriculture. Food supply chains have lengthened dramatically as the physical distance from farm to plate has increased; the consumption of processed, packaged and prepared foods has increased in all but the most isolated rural communities.

Nevertheless, persistent and widespread hunger and malnutrition remain a huge challenge in many parts of the world. The current rate of progress will not be enough to eradicate hunger by 2030, and not even by 2050. At the same time, the evolution of food systems has both responded to and driven changing dietary preferences and patterns of overconsumption, which is reflected in the staggering increases in the prevalence of overweight and obesity around the world.

Expanding food production and economic growth have often come at a heavy cost to the natural environment. Almost one half of the forests that once covered the Earth are now gone. Groundwater sources are being depleted rapidly. Biodiversity has been deeply eroded. Every year, the burning of fossil fuels emits into the atmosphere billion of tonnes of greenhouse gases, which are responsible for global warming and climate change.

All of these negative trends are accelerating in pace and intensity, and agriculture is an important part of the problem. Deforestation, mainly for farming, produces a significant share of global greenhouse gas emissions

and causes the destruction of habitats, the loss of species and the erosion of biodiversity. The incidence of natural disasters has increased fivefold since the 1970s. Deforestation, the degradation of natural buffers protecting coastlines and the poor state of infrastructure have increased the likelihood that extreme weather events will escalate into full-fledged disasters for affected communities and the economy. The lengthening of food chains and changes in dietary patterns have further increased the resource-, energy-, and emission-intensity of the global food system.

These trends threaten the sustainability of food systems and undermine the world's capacity to meet its food needs. Although the full implications of climate change on agriculture, forestry and fisheries are difficult to predict, it is expected that the impacts will be of different levels and of a different nature in each region, ecological zone and production system. Even small changes in the climate, for example slight shifts in annual rainfall or seasonal precipitation patterns, can severely affect productivity.

Can we sustainably feed a world population of 11 billion?

Looking ahead, the core question is whether today's agriculture and food systems are capable of meeting the needs of a global population that is projected to reach more than 9 billion by mid-century and may peak at more than 11 billion by the end of the century. Can we achieve the required production increases, even as the pressures on already scarce land and water resources and the negative impacts of climate change intensify? The consensus view is that current systems are likely capable of producing enough food, but to do so in an inclusive and sustainable manner will require major transformations.

This raises further questions. Can agriculture meet unprecedented demand for food in ways that ensure that the use of the natural resource base is sustainable, while containing greenhouse gas emissions and mitigating the impacts of climate change? Can the world secure access to adequate food for all, especially in the low-income regions where population growth is the most rapid? Can agricultural sectors and rural economies be transformed in ways that provide more and better employment and income-earning opportunities, especially for youth and women, and help stem mass migration to cities with limited labour-absorptive capacity?

Can public policies address the so-called 'triple burden of malnutrition', by promoting food systems that give affordable access to food for all, eliminate micronutrient deficiencies and redress the overconsumption of food? Can the huge problem of food losses and waste, estimated at as much as one-third of the total food produced for human consumption, be tackled? Can national and global regulatory structures protect producers and consumers against the increasing monopoly power of large, multinational, vertically integrated agro-industrial enterprises? Can the impacts of conflicts and natural disasters, both major disrupters of food security and the causes of vast migrations of people, be contained and prevented?

This raises further questions in another area: policy coherence. Can we overcome 'wickedness' in policy-making, where the lack of a coherent set of well-defined goals and processes means that the response to one aspect

of a problem (e.g. incentives to raise productivity) risks exacerbating others (e.g. depletion of natural resources)? Can we engage all stakeholders, including the private sector, farmer and consumer organizations, and other civil society players, in better decision-making, recognizing that more inclusive governance is essential to improving dialogue about the hard policy choices that need to be made?

The international community has recognized the challenges and the need for transformative change

The international community has recognized these challenges. In particular, the 2030 Agenda for Sustainable Development, adopted by the international community in September 2015, provides a compelling, but challenging, vision on how multiple objectives can be combined to define new sustainable development pathways. The second Sustainable Development Goal (SDG 2) explicitly aims at ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture, simultaneously by 2030.

The 2030 Agenda acknowledges that progress towards many other SDGs, especially the eradication of poverty and the response to climate change (SDG 13) and the sustainable use of marine and terrestrial ecosystems (SDG 14 and 15), will depend on the extent to which food insecurity and malnutrition are effectively reduced and sustainable agriculture is promoted. Conversely, progress towards SDG 2 will depend on progress made toward several of the other goals. In other words, in order to make progress on SDG 2, policy-makers and all other stakeholders will need to consider interlinkages and critical interactions, both in terms of synergies and trade-offs, between SDG 2 and all other goals.

The 2030 Agenda for Sustainable Development and the Addis Ababa Action Agenda on financing for development specifically call on all countries to pursue policy coherence and establish enabling environments for sustainable development at all levels and by all actors (SDG 17). The Paris Agreement on climate change, and the steps towards its implementation taken at the United Nations Climate Change Conference 2016 (COP22) in Marrakesh, reflect global commitments for concerted action to address the perils of climate change. The Sendai Framework for Disaster Risk Reduction also gives priority to the agriculture sectors. These, and other frameworks, and their relevance to FAO's work and mandates, are summarized in the Annex to this report.

Despite these promising international frameworks for action, achieving policy coherence will be challenging. The 2030 Agenda and other related global agreements stress the interdependence of the challenges they are to address. They also recognize the need to integrate different actions to achieve linked objectives and that doing so will pose new technical demands on policy-makers, at all levels, as well as new demands on institutional arrangements and coordination at various levels of governance.

The related challenges are twofold. First, different instruments implemented at different levels of governance will need to be combined in ways that are mutually reinforcing, while inevitable trade-offs are identified and contained. Second, capitalizing on synergies among SDGs and targets,

between different sectoral policies, and between diverse actions undertaken by officials and stakeholders at levels that range from local, municipal, and provincial to national, and from national to regional and international, has proven quite challenging in the past.

The purpose of this report is not to present a menu of solutions, but rather to increase understanding of the nature of the challenges that agriculture, rural development and food systems are facing now and will be facing into the 21st century. The analysis presented here of global trends and challenges provides further insights into what is at stake and what needs to be done. The following section assesses **15 Trends** that will shape the future of food and the livelihoods of those depending on food and agricultural systems. Most of the trends are strongly interdependent and, combined, inform a set of **10 Challenges** to achieving food security and nutrition for all and making agriculture sustainable. These challenges are presented in the final section of this report.

One clear message that emerges is that 'business-as-usual' is not an option. Major transformations of agricultural systems, rural economies and natural resource management will be needed if we are to meet the multiple challenges before us and realize the full potential of food and agriculture to ensure a secure and healthy future for all people and the entire planet.

Trends

Major drivers of change in the 21st century

1 Population growth, urbanization and ageing
2 Global economic growth, investment and trade
3 Increasing competition for natural resources
4 Climate change
5 Agricultural productivity and innovation
6 Transboundary pests and diseases
7 Conflicts, crises and natural disasters
8 Poverty, inequality and food insecurity
9 Nutrition and health
10 Structural change and employment
11 Migration and agriculture
12 Changing food systems
13 Food losses and waste
14 Governance for food security and nutrition
15 Development finance

1 | Population growth, urbanization and ageing

While, in general, world population growth is slowing down, in some regions population will continue to expand well beyond 2050 and even into the next century. More people now live in cites than in rural areas, and this discrepancy is projected to increase as population grows. Urbanization has been accompanied by a transition in dietary patterns and has had great impacts on food systems.

As a whole, the world population is growing older. Ageing is now also accelerating in low-income countries, where the process tends to start earlier and is becoming more pronounced in rural areas. Urbanization and ageing will have important repercussions on the agricultural labour force and the socio-economic fabric of rural communities. These population dynamics must be taken into account when charting sustainable development pathways that can ensure food security for all.

Global population growth is slowing, but Africa and Asia will still see a large population expansion

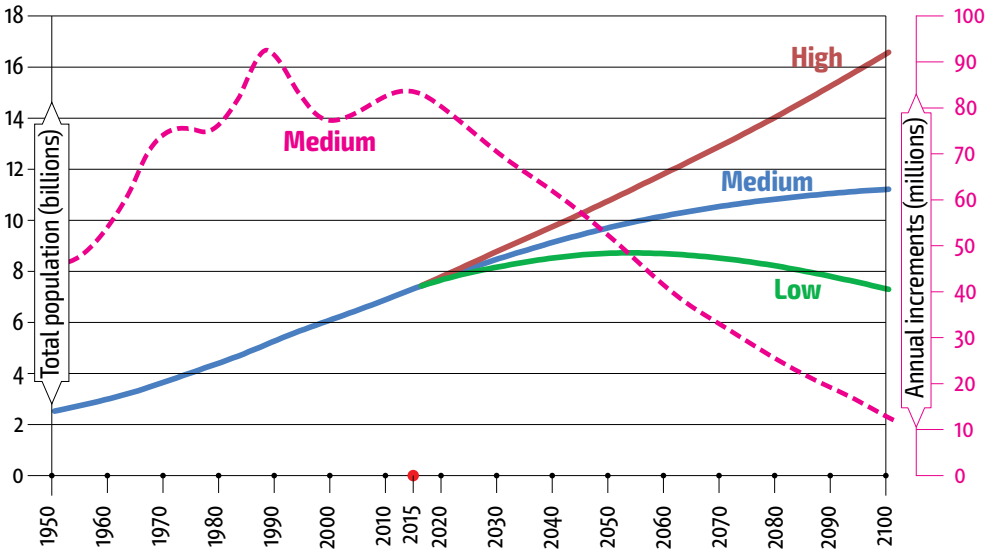
In its projections, FAO has always considered, as a key driver of changes in demand for food and agricultural products, not only population in absolute numbers but population dynamics, which includes diversity in regional trends, structure by age groups, and location (rural and urban).[1] The United Nations Population Division has estimated population growth in three different scenarios, known as the low, medium and high variants. Figure 1.1 illustrates the past evolution and the expected trends for each of these three variants. In the subsequent analysis, the medium variant will serve as the main reference.

For the world as a whole, annual population growth rates have been declining for nearly five decades. At their highest point in the late 1960s, global growth rates reached 2 percent per year, with total fertility rates (TFR) at levels of 4.5.[2] With TFRs declining to 2.5 in 2015, annual global population growth rates fell to 1.2 percent. Despite declining world population growth rates, absolute annual increments have continued to increase until very recently, when they started to decline noticeably. Currently, the absolute annual increments are slightly below 80 million people.

[1] See, for example, the FAO Global Perspectives Studies series, which investigates how food and agriculture may develop in the long term within the context of broader economic and social development. Recent publications include *World agriculture towards 2030/2050: the 2012 revision* (Alexandratos and Bruinsma, 2012), hereafter referred as AT2050 (available at www.fao.org/docrep/016/ap106e/ap106e.pdf). Another example is *Achieving zero hunger: the critical role of investment in social protection and agriculture* (FAO, IFAD and WFP, 2015), which is referred to in this publication as *AZH* (available at www.fao.org/3/a-i4951e.pdf).

[2] TFR is the average number of children that would be born to a woman over her lifetime if: (a) she were to experience the current age-specific fertility rates through her lifetime, and (b) she were to survive from birth through to the end of her reproductive life. A country's population size is stable when TFR is at a replacement level, which for the world as a whole is around 2.3 children per woman.

Figure 1.1 Global population growth to 2100, by variant



Note: Annual increments are 5-year averages.
Source: UN, 2015.

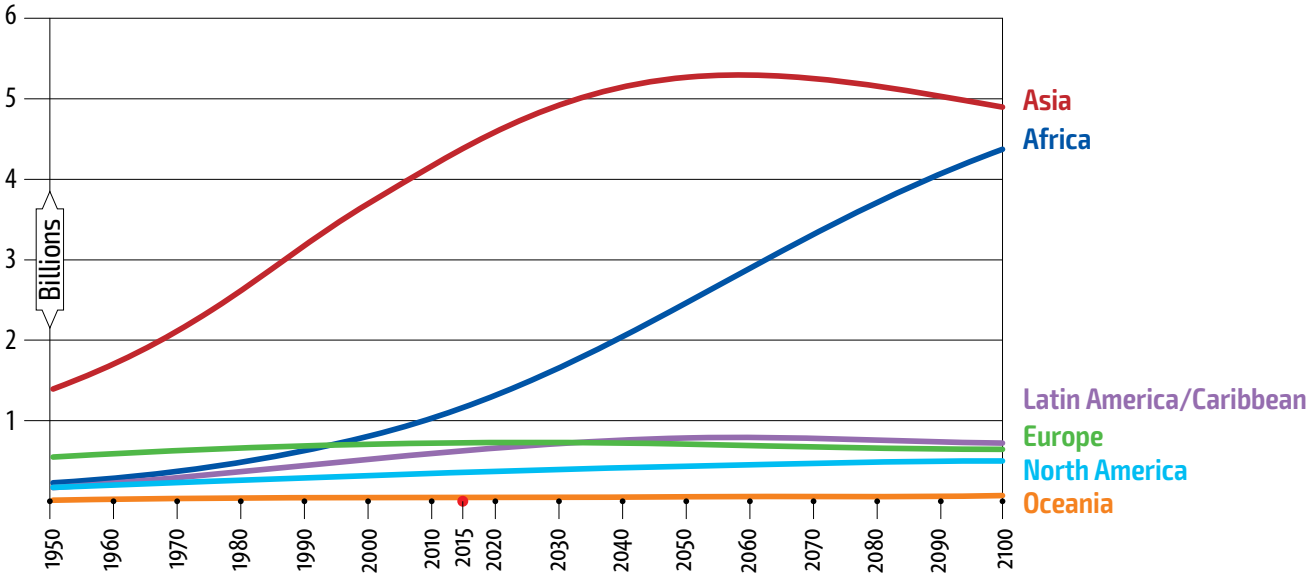
The medium variant suggests a gradual decline in absolute increments to slightly over 55 million people by 2050, and a further decline to 15 million per year by the end of the century. Cumulatively, these increments translate into a world population of 9.73 billion by 2050 and 11.2 billion by 2100.

The global trends mask considerable differences across and within regions and between high-income and middle- and low-income countries. While the high-income countries would reach their maximum population size by 2040, low- and middle-income countries would see only slow declines in growth over the medium and even the longer term. There are also considerable differences in population growth rates within low-income countries. Asia, the most populous continent, would reach its population peak between 2050 and 2060 (Figure 1.2).

East Asia is expected to see a continued and increasing deceleration of growth rates and a shrinking overall population after 2040. South Asia will continue to grow beyond 2070 and only reach its zenith sometime after that point. Growth is also expected to slow in Latin America, but more moderately, and the region will not reach its maximum population size before 2060. More rapid and more durable growth is projected for the Near East and North Africa region, where increases come to a halt only after 2080. The only region where the maximum population size will not be reached within this century is Africa. While the region's growth rate will continue to decelerate, its population is set to continue to expand beyond the end of the century and is expected to reach more than 2.2 billion by 2050 and more than 4 billion by 2100. The net effect across all regions will be a continuously growing global population, possibly surpassing 11.2 billion people by 2100.

The differences within regions are even more pronounced than the differences across regions. Some countries are currently projected to grow so rapidly that their populations would reach multiples of their current levels by 2050. At the top of the list of fast growing populations is Niger, with

Figure 1.2 Population growth to 2100, by region (medium variant)



Source: UN, 2015.

growth rates of 3.75 percent expected between 2015 and 2050, and 2.12 percent thereafter. Following the medium variant, Niger's population would expand from 20 million people today to 72 million by 2050, and 209 million people by 2100. Annual growth rates of more than 2.5 percent to 2050 are also projected for Angola, Burundi, Chad, the Democratic Republic of the Congo, Gambia, Malawi, Mali, Senegal, Somalia, the United Republic of Tanzania, Uganda and Zambia. All these countries are located in sub-Saharan Africa, with many of them in the central and eastern areas of the continent. The combined population of these countries reached 320 million people in 2015, and it will nearly double by 2050 and more than redouble by 2100 to reach a projected total of 1.8 billion.[3]

Should these population projections materialize, the increases could seriously jeopardize the overall development prospects of these countries. As all of these countries rely significantly on agriculture for employment and income generation, it would also hamper prospects for improving food security and nutrition. This holds particularly true for those agriculture-dependent countries with limited land and water resources, such as Niger and Somalia. Based on current trends, if these countries were to rely exclusively on domestic production for their food supply, they could be confronted with a neo-Malthusian future.

Rapid population growth changes the population structure, with younger generations making up an increasing share of the overall population. Between 2015 and 2050, in low- and middle-income countries, the number of people between 15 and 24 years of age is expected to rise from about 1 billion to 1.2 billion. Most of these young people are expected to live in sub-Saharan Africa and South Asia, particularly in rural areas, where jobs will likely to be difficult to find.

Without sufficient employment opportunities, this population trend may lead to a more rapid rate of outmigration. The impacts of outmigration are already being felt in some emigration destinations, not only at the national

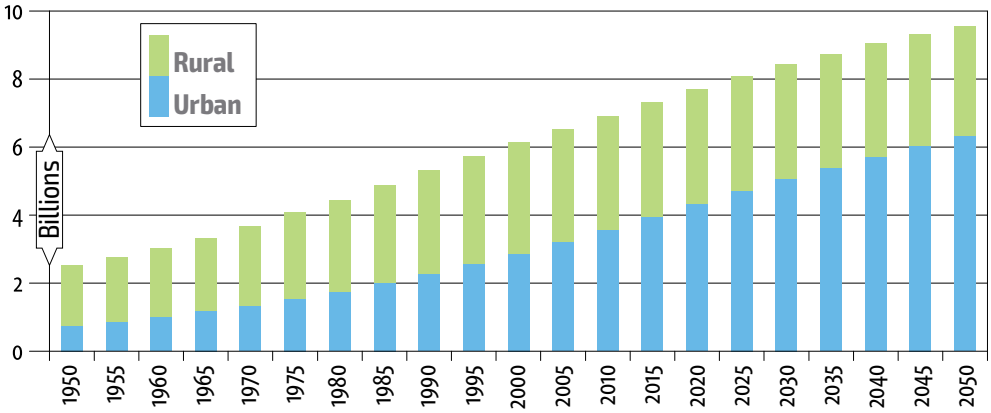
[3] In addition to these 13 African countries, a few Asian ones also currently have annual population growth rates above 2.5 percent: they are Afghanistan, Iraq, Lebanon and several small states in the Persian Gulf.

level, but also abroad, notably in Europe and high-income countries in other regions. These outmigration flows might be partially stemmed through family planning. However, more important are policies that promote decent employment and income earning opportunities, especially in rural areas.

Rapid urbanization is accelerating the dietary transition

For decades, the world's population was predominantly rural. Thirty-five years ago, more than 60 percent of all people lived in rural areas. Since then, the urban-rural balance has changed markedly, and today slightly more than half of the global population (54 percent) is urban. Thirty-five years from now, in 2050, more than two-thirds of all people may be living in urban areas (UN, 2015).[4] Changes in agriculture, notably technical progress and the adoption of labour-saving technologies, have helped underpin increasing urbanization. At the same time, agriculture, food and nutrition have been, and are likely to continue be, affected by the changes brought about by urbanization.

Figure 1.3 Growth in global urban and rural populations to 2050



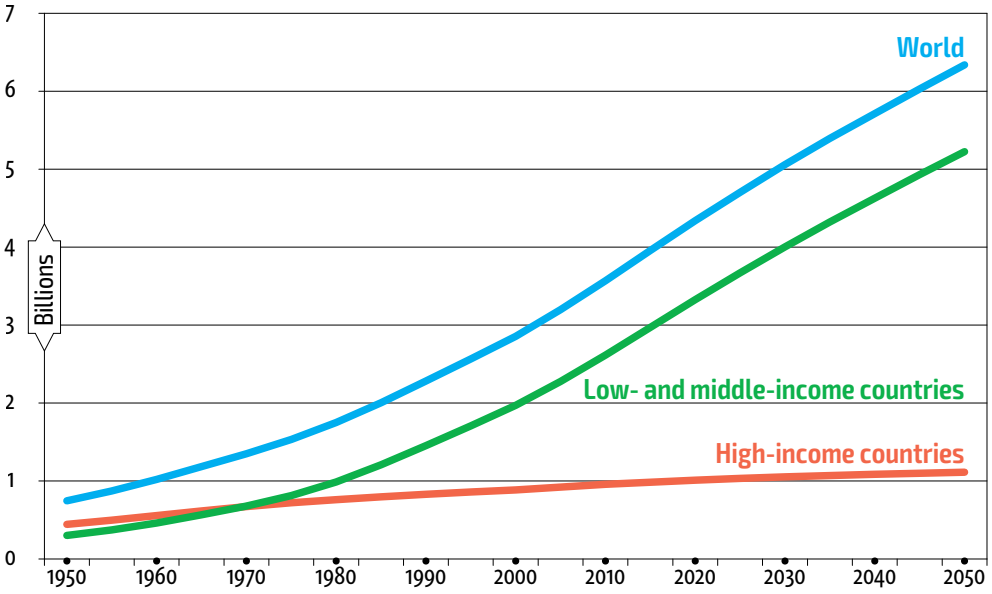
Source: UN, 2015.

In absolute terms, global urbanization to 2050 could lead to a net addition of 2.4 billion people to towns and cities, which is more than the total global population increment of 2.2 billion people. This means that rural populations may see a net reduction of nearly 200 million people (Figure 1.3). The net reduction of rural populations reflects much more than simply an outflow from rural to urban areas – it is driven by a variety of factors, notably higher mortality rates in rural areas and shorter life expectancies. These factors more than offset the lower urban fertility rates.

While urbanization was a high-income country phenomenon up to the 1970s, rapid growth in low-income countries has since become the defining feature of global urbanization dynamics. The sheer size of urban populations in low-income countries now determines the global dynamics (Figure 1.4).

[4] While this shift has been discussed and analysed widely, there is little appreciation for the quality of the underlying data. Importantly, urban/rural estimates, and hence projected urbanization trends, are not based on a uniform definition of urban versus rural populations. Instead, individual countries report their data based on national definitions and no effort has been made to make these estimates comparable across countries or regions.

Figure 1.4 Urbanization trends, by region



Source: UN, 2015.

While urbanization is now also prominent in low-income countries, the bigger picture obscures important differences across regions. Traditionally, Latin America has been the most urbanized developing region. South America, in particular, urbanized early and rapidly. By 1980, more than two-thirds of the region's population was classified as urban, a share that rose to nearly 85 percent in 2015. But its high degree of urbanization means that urbanization rates will decline, and future growth will remain small, while low-urbanized areas may urbanize faster in the future.

Urbanization impacts food consumption patterns. Higher urban income tends to increase demand for processed foods, as well as animal-source food, fruits and vegetables, as part of a broad dietary transition. Higher urban wages also tend to increase the opportunity costs of preparing food and favour food products that have a large amount of labour embedded in them, such as fast food, store-bought convenience foods and foods prepared and marketed by street vendors. With these changes, the nutrient content of diets is changing. Typically, diets are becoming higher in salt, fat and sugar and are, in general, more energy-dense. This shift in consumption patterns also means a shift in employment within the food system: fewer people work in agriculture and more work in transport, wholesaling, retailing, food processing and vending (Cohen and Garrett, 2009).

Ageing will also accelerate among rural populations

In the coming decades, the world is likely to be not only more populous and urban, but also demographically older. This is not a new trend. From 1950 to 2015, the share of children below the age of five declined from 13.4 percent to 9.1 percent, and the proportion of older (65+) people rose from 5.1 percent to 8.3 percent. This development is expected to accelerate. By the end of the century, the share of young children could decline to 5.8 percent, while the proportion of older people is forecast to rise to 22.7 percent (UN, 2015).

Beneath these global averages, there are significant differences across countries and continents. In high-income countries, ageing has matured. The next 20 to 25 years may see further increases in old age dependency rates before they gradually level off. Over the next 15 years, the number of older persons is expected to grow fastest in Latin America and the Caribbean, with a projected 71 percent increase in the population aged 65 and above, followed by Asia (66 percent), Africa (64 percent), Oceania (47 percent), North America (41 percent) and Europe (23 percent).

For decades, ageing in high-income countries was perceived as a 'success story'. People were, and are, living longer and generally healthier lives thanks improved nutrition, public health services and medical advances that have resulted in steadily growing life expectancies. Societies have had a large and healthy work force that contributed to income growth and supported a small dependent population, providing pensions and health care for older people and education for the young. These trends may now be changing. With ageing, the economic growth potential of the economy slows, social security systems become unsustainable and health-care burdens increase.

Most high-income nations have had decades to adjust to these changes in their age structures. For example, it took more than a century for France's population aged 65 and above to increase from 7 to 14 percent of the total population. In contrast, many low-income countries are experiencing a much more rapid increase in the number and percentage of older people, often without having reaped the same demographic dividends as slowly ageing high-income economies. Many low-income countries may not reach the income levels of high-income countries in the foreseeable future. They may 'grow old before they can grow rich'.

Ageing in rural areas tends to start earlier and proceed faster than national averages would indicate. Rural ageing has major implications for the composition of the rural labour force, patterns of agricultural production, land tenure, social organization within rural communities, and socio-economic development in general. Environmental degradation, climate change and limited agricultural technology tend to affect older farmers more than their younger, healthier and better-educated counterparts. The disadvantages faced by older farmers may be compounded by discrimination against older rural people in accessing credit, training and other income-generating resources. Agricultural innovations, such as the diffusion of new agricultural technologies and the introduction of improved seeds and tools, often bypass older farmers, as many have neither the financial resources to buy additional inputs, nor the skills (e.g. literacy) nor energy to invest in adopting new practices. Older women are particularly disadvantaged because gender divisions in agricultural production limit their opportunities to obtain credit and training, or participate in market exchanges.

In countries where the agricultural labour force is ageing, the adaptation of farming technologies and agricultural policies to the capacities and needs of older farmers could help to keep older people engaged in productive activities (Anriquez and Stloukal, 2008). In areas experiencing 'compressed ageing', the provision of social services may involve the adaptation of social support systems to accommodate the new age structure.

2 | Global economic growth, investment, trade and food prices

The world economy grew by 2.6 percent a year to almost double in size between 1990 and 2014. During that period, global economic growth was driven mainly by low- and middle-income countries, whose gross domestic product (GDP) grew by some 5.1 percent annually. China's GDP grew at double that rate, by more than 10 percent a year, and in 2014 the country accounted for 9 percent of global GDP, compared to just 2 percent in 1990 (UN, 2016).

The income of the average world citizen is now about 1.4 times higher than what it was in 1990. But there are marked regional differences. Per capita income in emerging East Asia and the Pacific increased by 7.4 percent annually between 1990 and 2014; in contrast, average income growth in sub-Saharan Africa stood at a meagre 1.1 percent a year, a reflection of starkly diverging growth patterns among low- and middle-income regions.[1]

Scenarios portray very different outlooks for GDP growth

The pathways followed by economic systems depend on a wide range of factors, such as the behaviour of producers and consumers, technological change, resource availability and productivity, and population dynamics. Little is known about the impacts of climate change on these systems, which adds to uncertainty about future income growth. Likewise, uncertainty about policy responses, and about institutional and political developments, makes it hard to project global income growth with any certainty. It makes sense, when making long-term economic projections, to use scenarios that reflect alternative assumptions about how these factors might evolve.

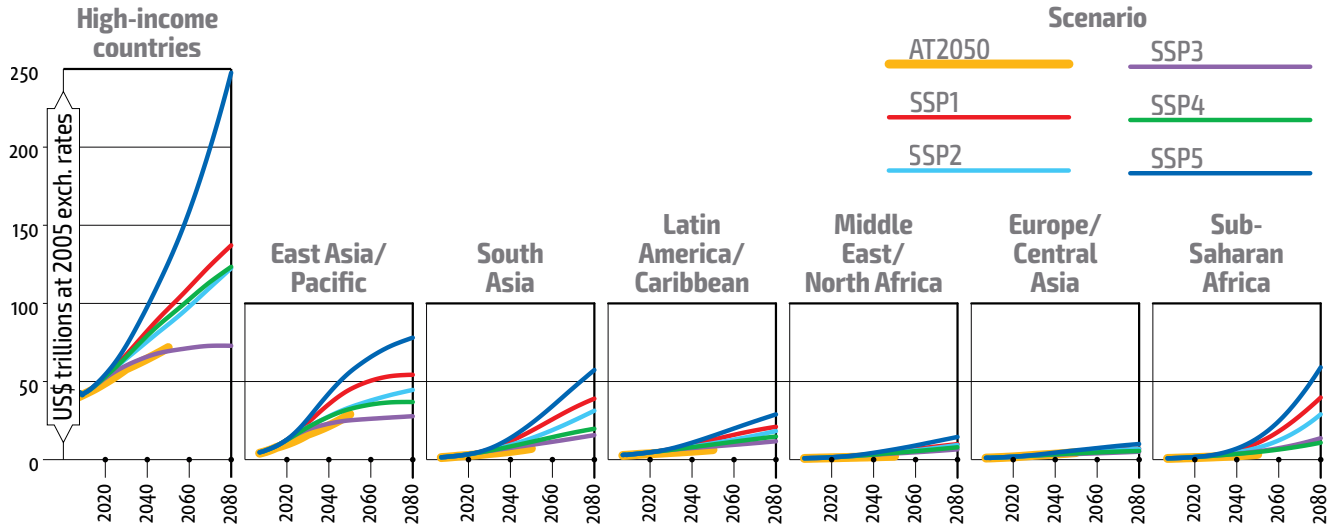
One set of scenarios, called 'Shared Socioeconomic Pathways' (SSPs), was developed for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (O'Neill *et al.*, 2015). Each scenario depicts a possible alternative future: global sustainability (SSP1); business-as-usual or middle of the road (SSP2); international fragmentation (SSP3); increasing between- and within-country inequality (SSP4); and a future in which fossil fuels remain the main source of energy (SSP5).[2] In all regions, the different scenarios trace very different trajectories for GDP growth (Figure 2.1).[3] The fossil-fuelled scenario (SSP5) consistently shows the highest GDP growth,

[1] In 1990, sub-Saharan Africa ranked third to last among the regions in terms of per capita annual GDP (US$922, measured at constant 2005/2007 prices); the second to last was East Asia and the Pacific (US$586); the last was South Asia (US$403). Largely as a result of higher economic growth, by 2014 East Asia and the Pacific had become the third to last region (US$3 285), sub-Saharan Africa the second to last (US$1 201) and South Asia the last region (US$1 107).

[2] The GDP and population projections related to the various SSPs are available from the International Institute for Applied Systems Analysis (IIASA) (available at https://secure.iiasa.ac.at/web-apps/ene/SspDb/).

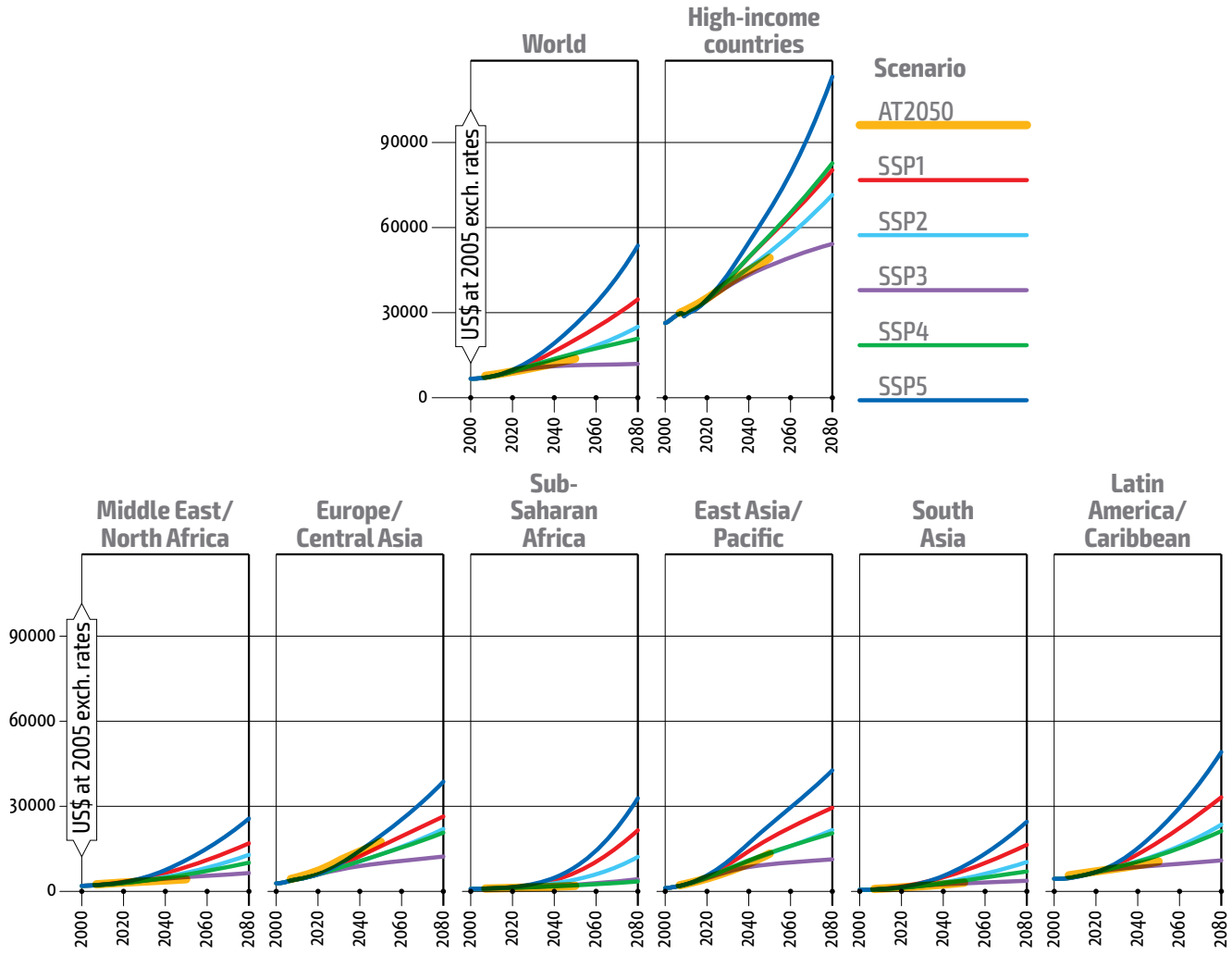
[3] To the extent possible, given changes in country status and the heterogeneity of country groupings in the different studies referred to, country aggregations in this report follow the country groupings used in the World Bank's list of economies as of July 2016. Regional groupings exclude high-income countries, as they are reported separately.

Figure 2.1 Projections of GDP growth, by region



Note: Regional groups do not include high-income countries.
Source: FAO Global Perspectives Studies, based on IIASA, 2016; Alexandratos and Bruinsma, 2012.

Figure 2.2 Projections of per capita GDP growth, by region



Note: Regional groups do not include high-income countries.
Source: FAO Global Perspectives Studies, based on IIASA, 2016; Alexandratos and Bruinsma, 2012.

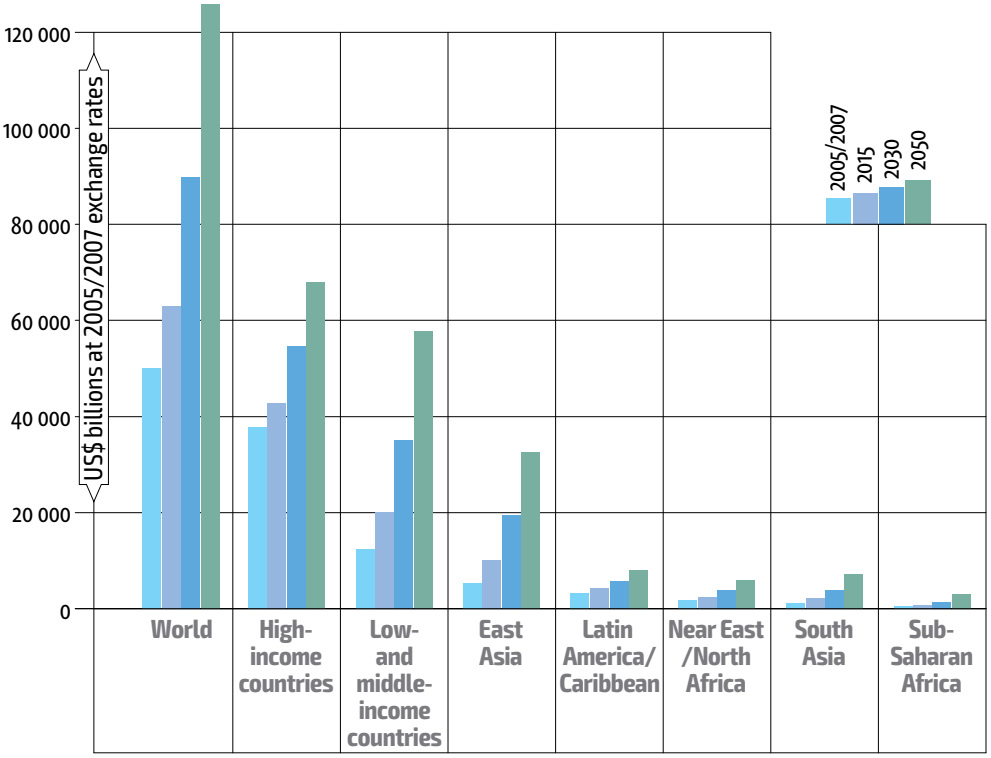
while fragmentation (SSP3) shows the lowest. In all scenarios, and despite their lower annual growth rates, high-income countries would still generate more than half of global GDP in 2080.

Figure 2.2 shows that per capita income projections to 2080 vary widely across scenarios and country groups. For instance, projections for SSP2, the middle-of-the-road scenario, show per capita global GDP increasing by 132 percent between 2000 and 2050 and doubling by 2080. This implies an average annual growth rate of 1.9 percent. The SSP5 scenario assumes much faster economic growth – per capita incomes would more than triple between 2000 and 2050 and quintuple by 2080. In contrast, SSP3 shows greater inequality and divergence, ending in much slower growth in per capita income worldwide.

FAO projections for agriculture assumed moderate rates of long-term economic growth

FAO's most recent projections of future patterns of agricultural demand and supply are based on moderate global economic growth to 2050, at a pace which is slower than in most of the SSPs. The FAO report *World agriculture towards 2030/2050*, or AT2050 (Alexandratos and Bruinsma, 2012), assumes an annual growth rate for the world economy of 2.7 percent. Accordingly, global GDP would increase from about US$50 trillion in 2005–2007 to almost US$126 trillion (in constant 2005 prices) in 2050 (Figure 2.3).

Figure 2.3 Growth in GDP to 2050, by region



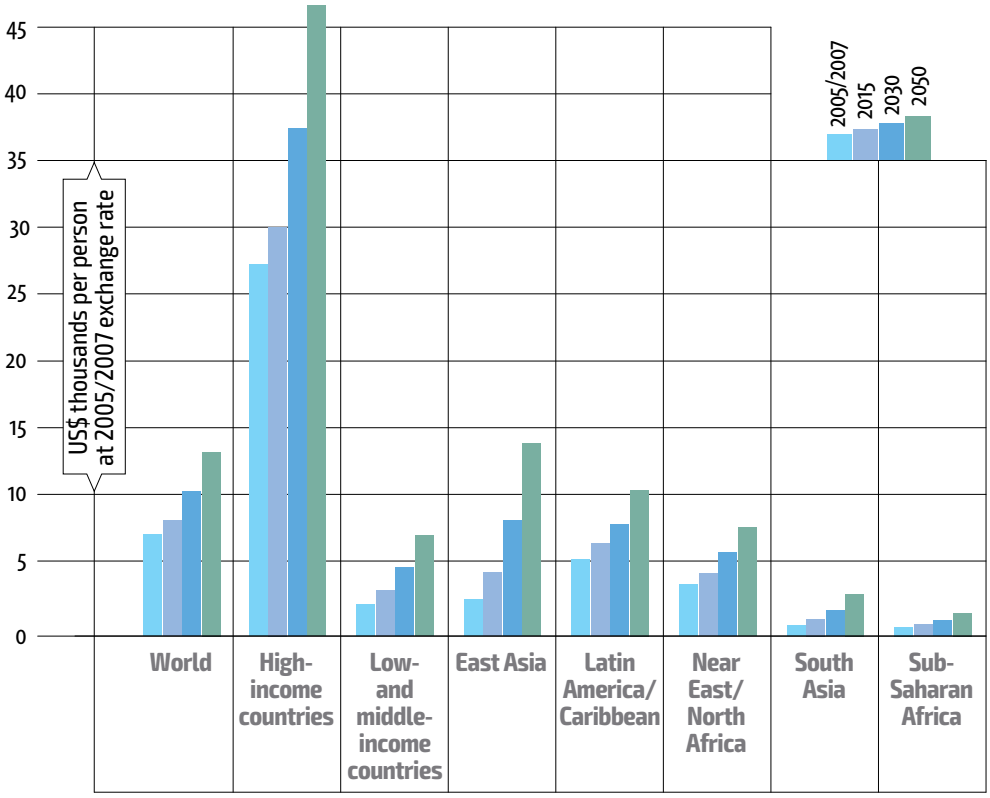
Note: Regional groups do not include high-income countries.

Sources: Data for 2015 are based on FAO Global Perspectives Studies (unpublished data); data for 2005–2007, 2030 and 2050 are based on Alexandratos and Bruinsma, 2012.

The projections used in AT2050 further assume some degree of economic convergence because low- and middle-income countries would continue to enjoy faster per capita income growth rates than high-income countries (Alexandratos and Bruinsma, 2012). Under these assumptions, sub-Saharan Africa would see its share in global GDP increase from less than 1 percent in 2005–7 to 2.3 percent in 2050. Of the five SSPs, four project higher GDP per capita to 2050. Only SSP3, the pathway of much greater global inequality, projects lower per capita GDP than the one assumed in AT2050, as shown in Figure 2.2.

AT2050 assumes that GDP per capita at the global level would increase between 2005–7 and 2050 from US$7 600 to US$13 800, an average annual growth rate of around 1.4 percent (Figure 2.4). The global average hides significant differences between low- and middle-income countries and high-income. Per capita GDP is assumed to more than triple in the former group, rising from US$2 400 to US$7 500, an average annual growth rate of 2.7 percent. Growth in high-income countries, in contrast, would be much slower, at around 1.2 percent a year. Despite this difference in growth to 2050, the average incomes of the population of low- and middle-income countries would remain only a fraction of those of people living in high-income countries, rising from 8.5 percent in 2005–7 to 16 percent. Furthermore, given the large difference in initial levels of per capita GDP, the income gap would continue to widen in absolute terms, from US$25 500 to almost US$40 000.

Figure 2.4 Growth of per capita GDP to 2050, by region



Note: Regional groups do not include high-income countries.

Source: Data for 2015 are based on FAO Global Perspectives Studies (unpublished data); data for 2005–2007, 2030 and 2050 are based on Alexandratos and Bruinsma, 2012.

Changing assumptions regarding GDP per capita will affect the projections of quantities, values and composition of agricultural demand, particularly for low- and middle-income countries, where the reactions of consumers to changes in income are expected to be stronger, in terms of their demand for food, than in high-income countries. Less conservative hypotheses than those adopted in AT2050, such as those of most SSPs, would shift the demand for agricultural goods upwards. More importantly, however, the rise of a global middle class, as a result of the fast income growth in emerging countries, has accelerated dietary transitions that are changing the composition of the demand for food. The trend is strongly towards higher consumption of meat and dairy products and other more resource-intensive food items, hence with implications for the sustainable use of natural resources.

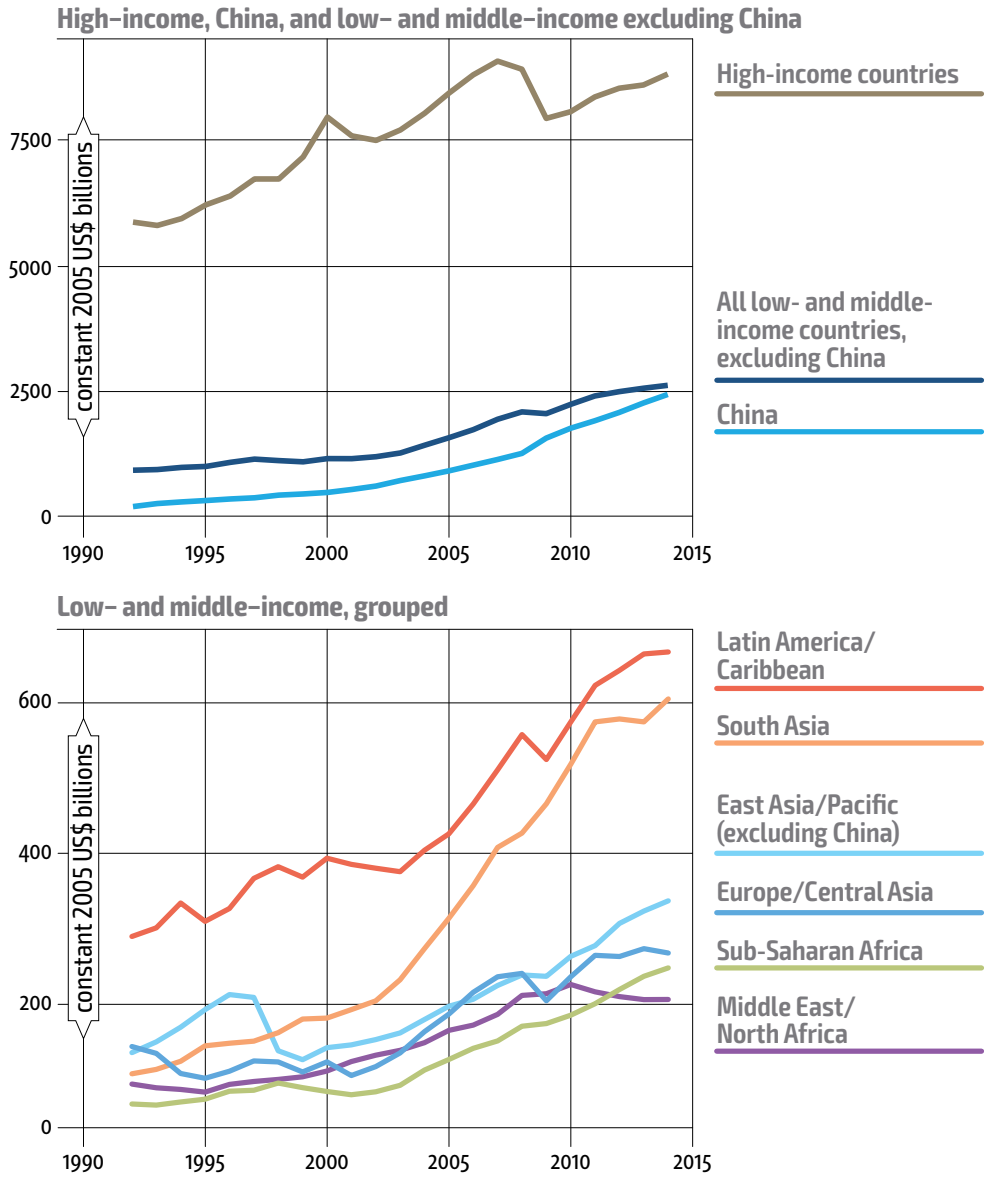
Investments are on the rise, especially in China

Global levels of economy-wide investment (or gross fixed capital formation), have increased over the past 25 years (Figure 2.5). Investment growth in high-income countries averaged less than 2 percent a year between 1991 and 2014. Investment levels fell by almost 15 percent in these countries as a consequence of the 2008–09 global financial crisis. By 2014, investment levels had recovered to the pre-crisis level of around US$9 trillion (at constant prices of 2005).

The level of gross investment in East Asia and the Pacific has increased dramatically over the past quarter century. It grew from just US$300 billion in 1990 to reach US$2.8 trillion in 2014, mainly thanks to the China, where investment increased at an annual rate of around 15 percent. In 2014, China accounted for more than 85 percent of investment in the region. Investment growth in other low- and middle-income countries has been much slower, expanding at slightly more than 4 percent a year.

While investment levels have increased, investment rates have remained almost stagnant in high-income countries, at around 22 percent of GDP (Figure 2.6). China, in contrast, boosted its economy-wide investment from 28 percent to around 45 percent of GDP between 1990 and 2015; investment rates in other low- and middle-income countries followed a U-shaped pattern. Even in sub-Saharan Africa, where the investment rate is well below that of other low- and middle-income regions, there is upward movement following a downward trend between 1995 and 2005.

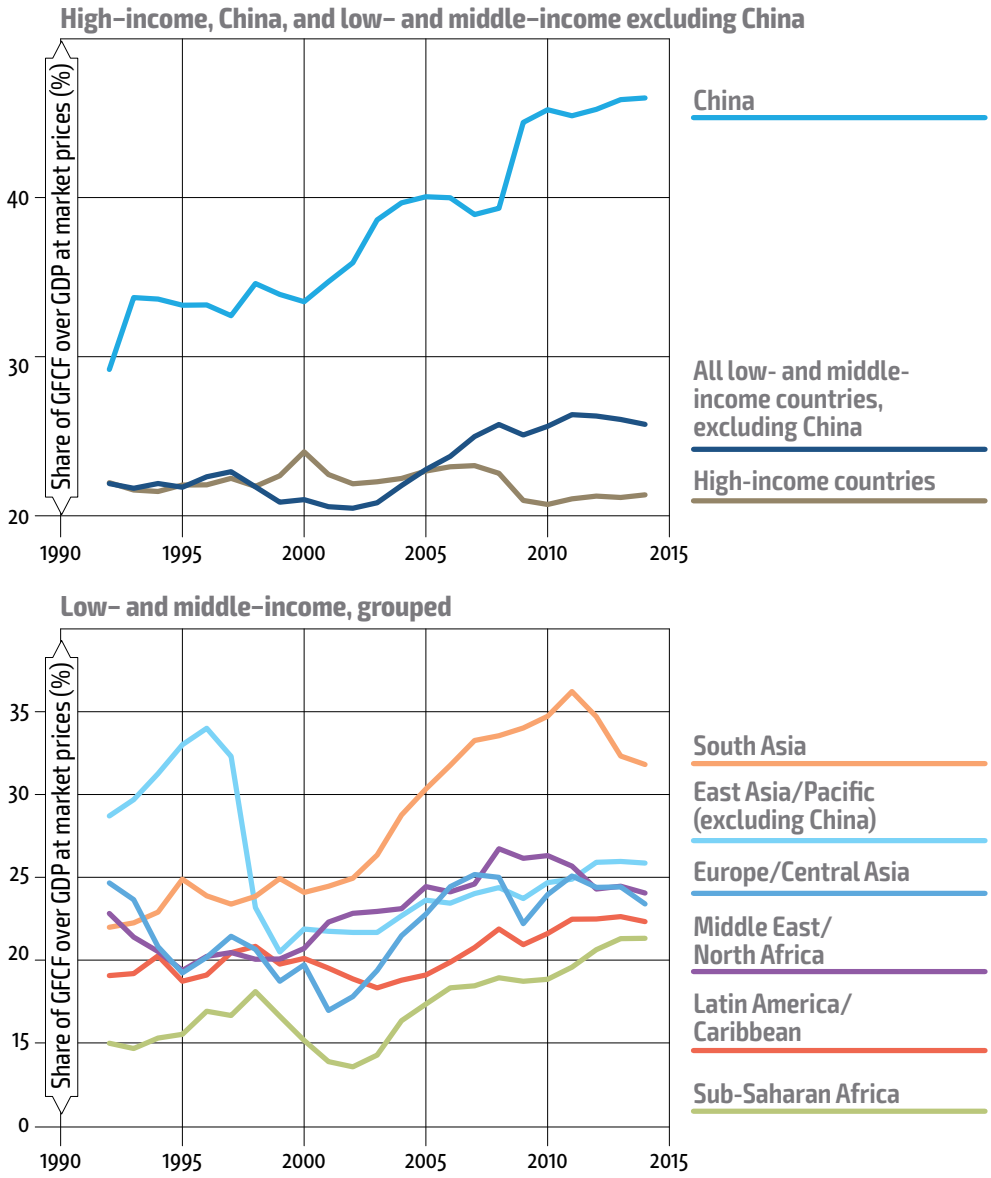
Figure 2.5 Gross Fixed Capital Formation (GFCF), by region, 1990–2015



Note: Regional groups do not include high-income countries.

Source: FAO Global Perspectives Studies, based on UN, 2016.

Figure 2.6 Investment rates, by country group and region, 1990–2015

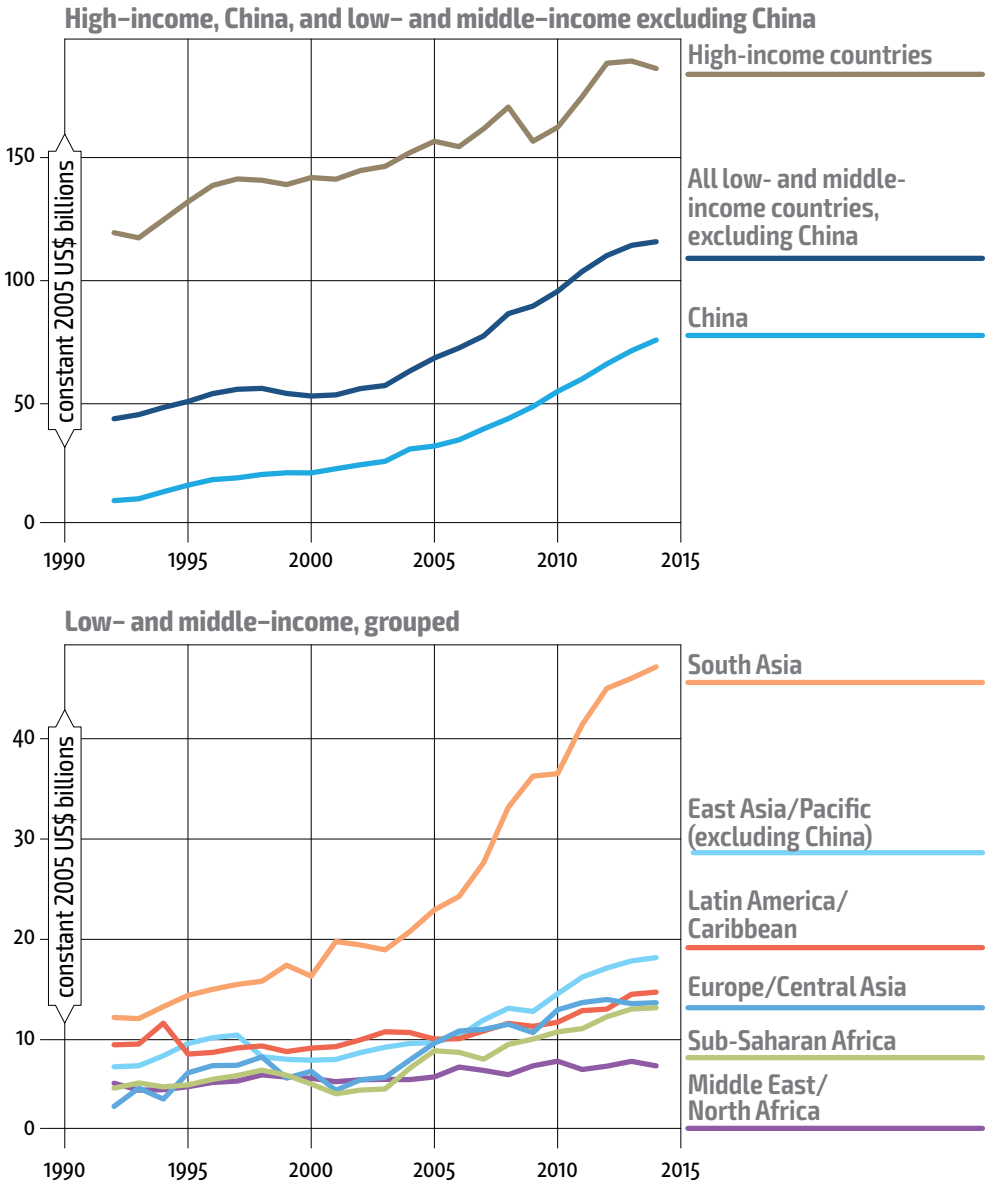


Note: Regional groups do not include high-income countries.
Source: FAO Global Perspectives Studies, based on UN, 2016.

Agriculture remains much less capital intensive in low- and middle-income countries

Trends in investment in agriculture display a somewhat different picture. Nowadays, low- and middle-income countries invest in agriculture almost as much, in absolute terms, as high-income countries – around US$190 billion in both country groups. In the period 1991–2014, agricultural investment levels increased in all country groupings, although at different rates. In high-income countries, investment increased from around US$120 billion to US$190 billion (Figure 2.7), an annual average growth rate of around 2 percent. In China, it grew from less than US$10 billion to US$75 billion, a growth rate of around 9 percent, while investment in agriculture in the remaining low- and middle-income countries grew from US$45 billion to US$115 billion, a growth rate of around 4 percent.

Figure 2.7 Gross Fixed Capital Formation (GFCF) in agriculture, by country group and region, 1990–2015

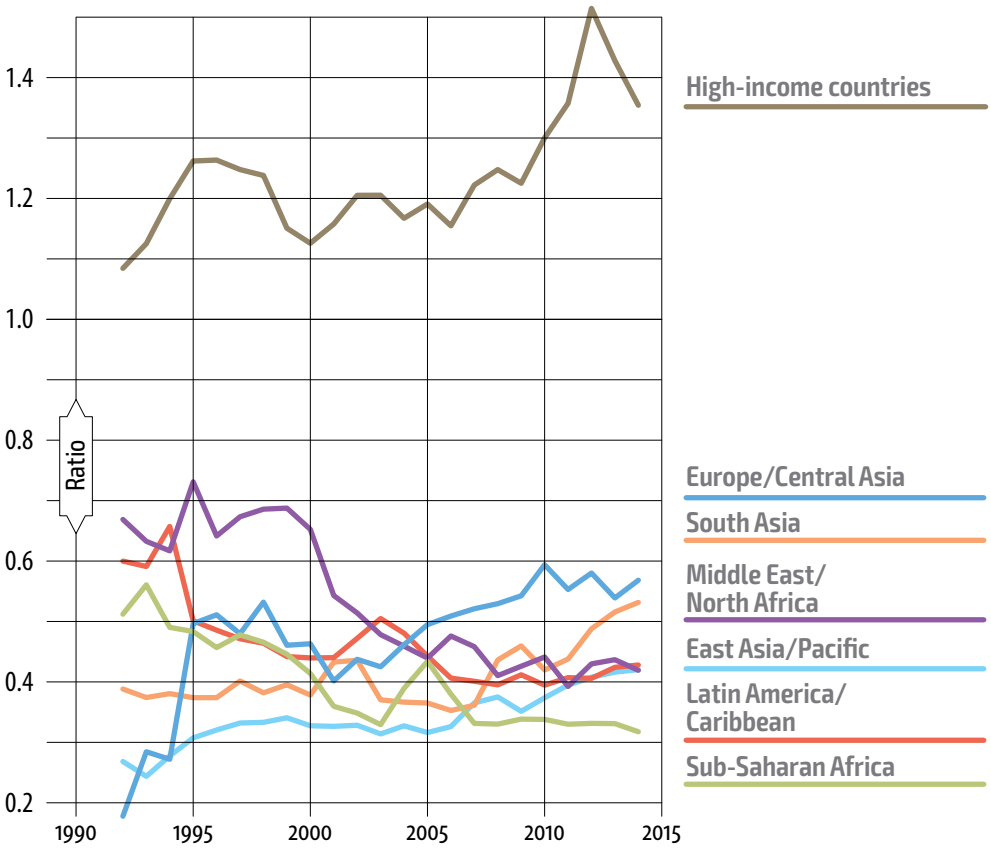


Note: Regional groups do not include high-income countries.
Source: FAO Global Perspectives Studies, based on FAO, 2016a.

The preponderance of low- and middle-income countries in global investments in agriculture does not imply the sector is seen as more important, relative to its size. A comparison between the shares of agricultural investment in total investment and the shares of agricultural value added in GDP reveals important structural differences across groups of countries, as well as different dynamics.

First, only in high-income countries is the agricultural investment share larger than agricultural value added share. In the last two decades, high-income countries have always devoted a larger share of investment to agriculture than the share of the sector in GDP. This is reflected in the fact that the 'agricultural investment orientation ratio' has remained

Figure 2.8 Agricultural investment orientation ratio by region, 1990–2015



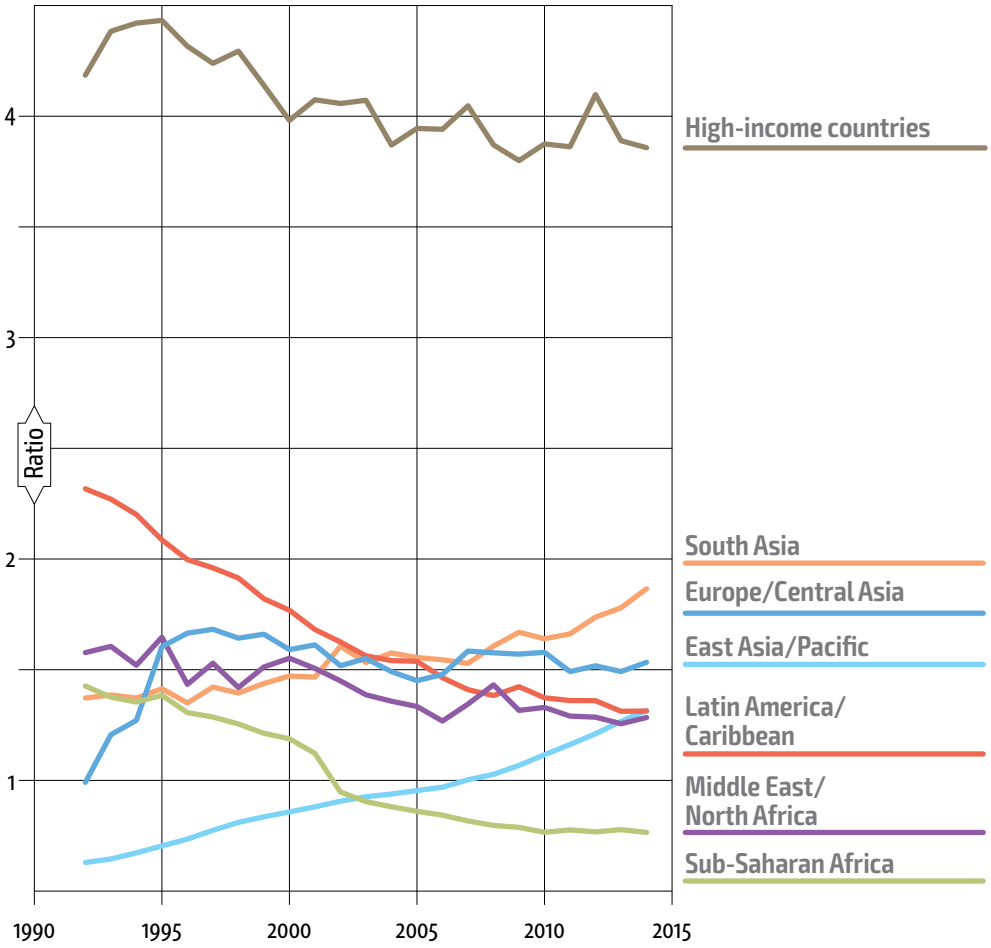
Note: Regional groups do not include high-income countries. The agricultural investment orientation ratio is defined here as the ratio of the share of gross fixed capital formation in agriculture in total gross fixed capital formation over the share of agricultural value added in total GDP.

Source: FAO Global Perspectives Studies, based on UN, 2016 for agriculture value added, GDP and total gross fixed capital formation; based on FAO, 2016a for gross fixed capital formation in agriculture.

consistently above 1 (Figure 2.8). In low- and middle-income countries, in contrast, this ratio is much lower, at around 0.4. Second, diverging patterns across regions have developed in the past two decades. While the investment orientation ratio is increasing in high-income countries, East Asia and the Pacific (including China), South Asia, Europe and Central Asia, it is decreasing in the Middle East, North Africa, sub-Saharan Africa and, to some extent, Latin America and the Caribbean.

Degrees of capital intensity in agriculture sectors also vary. Figure 2.9 shows that agriculture in high-income countries is significantly more capital-intensive than in low- and middle-income countries – it requires 4 units of capital to generate one unit of value added, compared to around 1.5 in low- and middle-income countries. However, in East Asia and the Pacific (including China), South Asia, Europe and Central Asia, the capital-intensity of agricultural production is increasing. While this cannot be univocally interpreted as a signal of convergence towards the type of agriculture found in high-income countries, it may indicate that capital is progressively replacing other inputs and factors, particularly labour. In fact, the share of labour employed in agriculture in these regions is decreasing. In contrast, in the Middle East and North Africa, sub-Saharan Africa, and Latin America and the Caribbean, capital-intensity has fallen.

Figure 2.9 Agricultural net capital-output (value added) ratio, 1990–2015



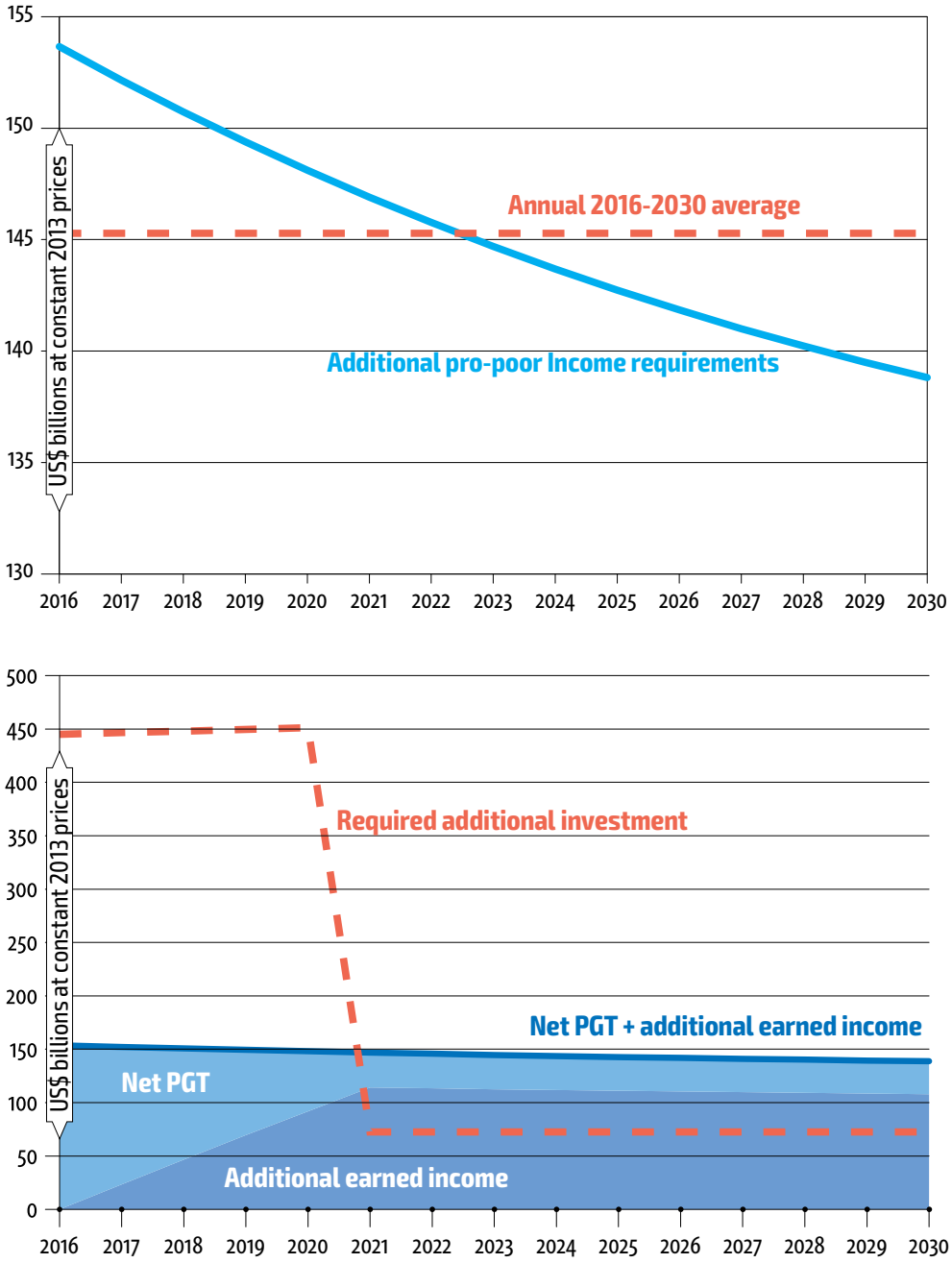
Note: Regional groups do not include high-income countries. The agricultural capital-output ratio is defined as the net fixed capital formation in agriculture as a share of agricultural value added (GDP).
Source: FAO Global Perspectives Studies, based on FAO, 2016a.

'Business-as-usual' investment patterns would leave hundreds of million people undernourished to 2030

A study prepared by FAO, along with the International Fund for Agricultural Development (IFAD) and the World Food Programme (WFP), showed that, on current investment patterns and spending on social protection, there would be no improvement in income growth and access to food sufficient to eradicate hunger by 2030. Under a business-as-usual scenario, the prevalence of hunger would fall, but more than 650 million people, or 8 percent of the global population, would still be undernourished in 2030 (FAO, IFAD and WFP, 2015).

The report estimated that, globally, additional investments required to end hunger by 2030 would amount to US$265 billion a year. These investments would be needed for both social protection programmes (US$67 billion), which would improve access to food for vulnerable populations, and for investment in pro-poor productive activities (US$198 billion) that provide low-income earners with structural opportunities to earn, save, invest and improve their livelihoods.

Figure 2.10 Additional income and investment to eradicate hunger by 2030



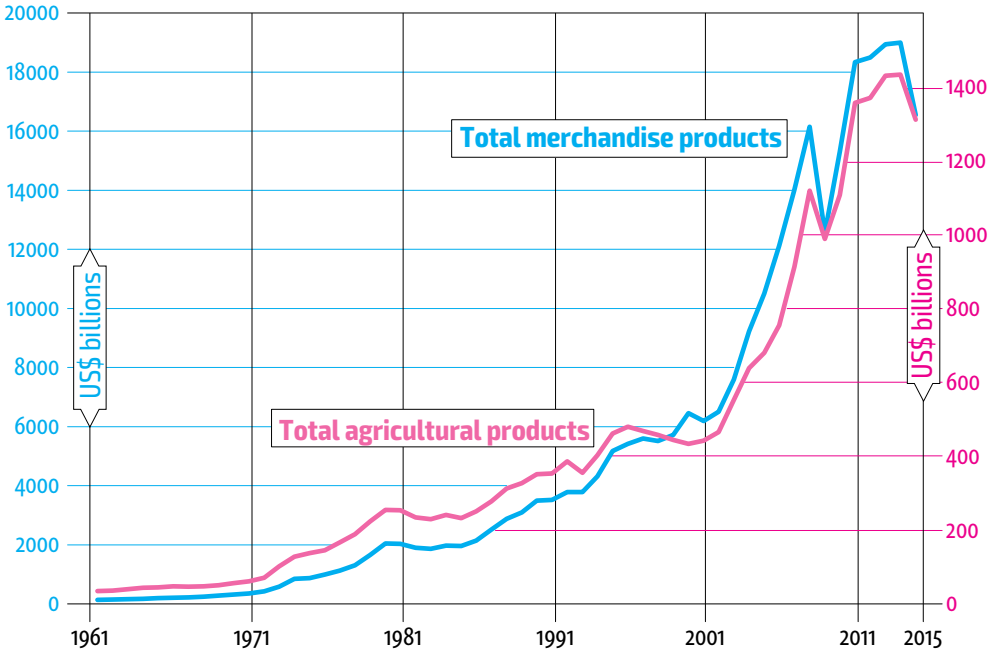
Note: 'PGT' is Poverty Gap Transfer.
Source: FAO, IFAD and WFP, 2015.

While social protection, identified by the Poverty Gap Transfer (PGT), is expected to provide a great proportion of the required additional income until 2020–21 (light blue area in Figure 2.10, bottom), additional earned income (dark blue area) may progressively outpace income from social protection, thanks to significant investment in the early years of the period (red dashed line, Figure 2.10, bottom). These investments are expected to provide people currently living in extreme poverty with an average of around US$145 billion of additional annual income, which they need to escape from hunger and extreme poverty by 2030 (red dashed line, top).

Agricultural trade follows global economic trends

Figure 2.11 shows how international trade in agricultural products accelerated rapidly from the start of the new millennium, but slumped with the global financial crisis of 2008–09. Some recovery took place after 2009, but growth has been sluggish since. These developments are now commonly referred to as the 'global trade slowdown' (Financial Times, 2014). Preliminary data for 2014 suggest that this slowdown entered a new contraction during 2015, with only very minor recovery since (CPB, 2016).

Figure 2.11 Total and agricultural international trade volume, 1961–2015



Source: Data from 1961–2013 are based on FAO, 2016a; data for 2014 and 2015 are based on ITC, 2016.

Trends in trade are mainly explained by business cycles in the global economy. Trade policies and trade agreements also play a role, but their impact is more difficult to gauge. The lack of progress in multilateral trade negotiations under the auspices of the WTO, notably the failure to conclude the Doha Development Agreement and a partial relapse into protectionist policies after the global financial crisis, may have compounded the slowdown in global trade.

Three large regional trade agreements (RTAs) have recently been concluded or are under negotiation: the Trans-Pacific Partnership (TPP), the Regional Comprehensive Economic Partnership (RCEP), and the Trans-atlantic Trade and Investment Partnership (TTIP). All three include, or at least affect, agriculture. They aim at further liberalizing agricultural trade, changing rules on food safety, animal and plant health, and harmonizing food product standards. These RTAs are also expected to address legal rights and obligations associated with the use of names of certain foods and wines in international trade, and address the scope of patent protections available for plants. Also on the negotiating table are additional regulations on the use of subsidies for agricultural exports and the circumstances under which agricultural export restrictions could be imposed.[4]

[4] See Jurenas, 2015. See also: Falconer, 2015 and Yamashita, 2015.

Border protection for agricultural imports of the countries negotiating these agreements range considerably, from close to zero for Australia and New Zealand to high on certain commodities imported by Japan and Canada. Except for the European Union and the United States of America, many of the countries involved in the TPP and RCEP have already entered into bilateral RTAs that have eliminated tariffs on many commodity and food imports or are in the process of phasing them out.[5]

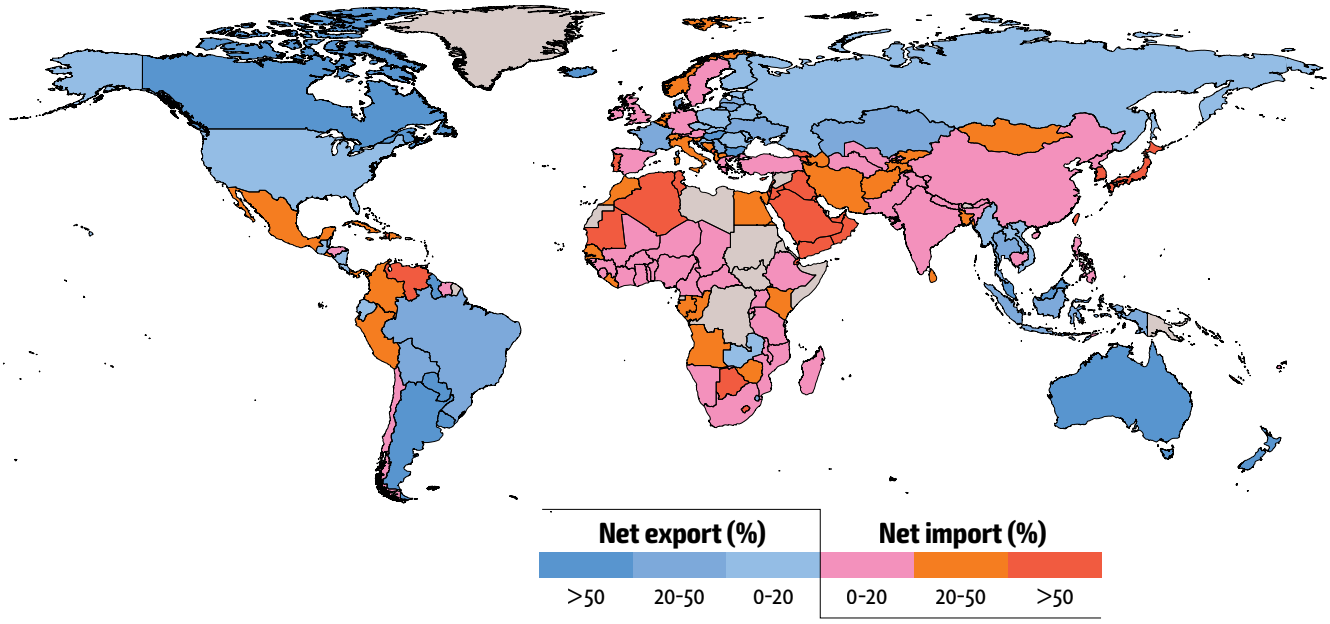
Some low-income countries fear that the elimination of tariffs and quotas on agricultural products, being negotiated among RTA partners, could erode the tariff preferences that have given their agricultural exports a competitive edge in those countries. The rules of origin crafted in each of the mega-regions could affect the extent to which agricultural commodities from third countries are utilized as inputs by each trade bloc's food processing sectors. Another fear is that strengthened TPP and TTIP regulatory disciplines and processes would institutionalize how rules on Sanitary and Phytosanitary Measures and Technical Barriers to Trade are applied, and set the stage for more rigorous standards that third-country exporters of agricultural products might find more difficult and costly to meet.

[5] Where tariffs and quotas remain, particularly on sensitive agricultural commodities, market access talks are focused on the target of comprehensively eliminating border protection but are directed to take these sensitivities into account.

Agricultural trade has expanded, but most food is supplied domestically

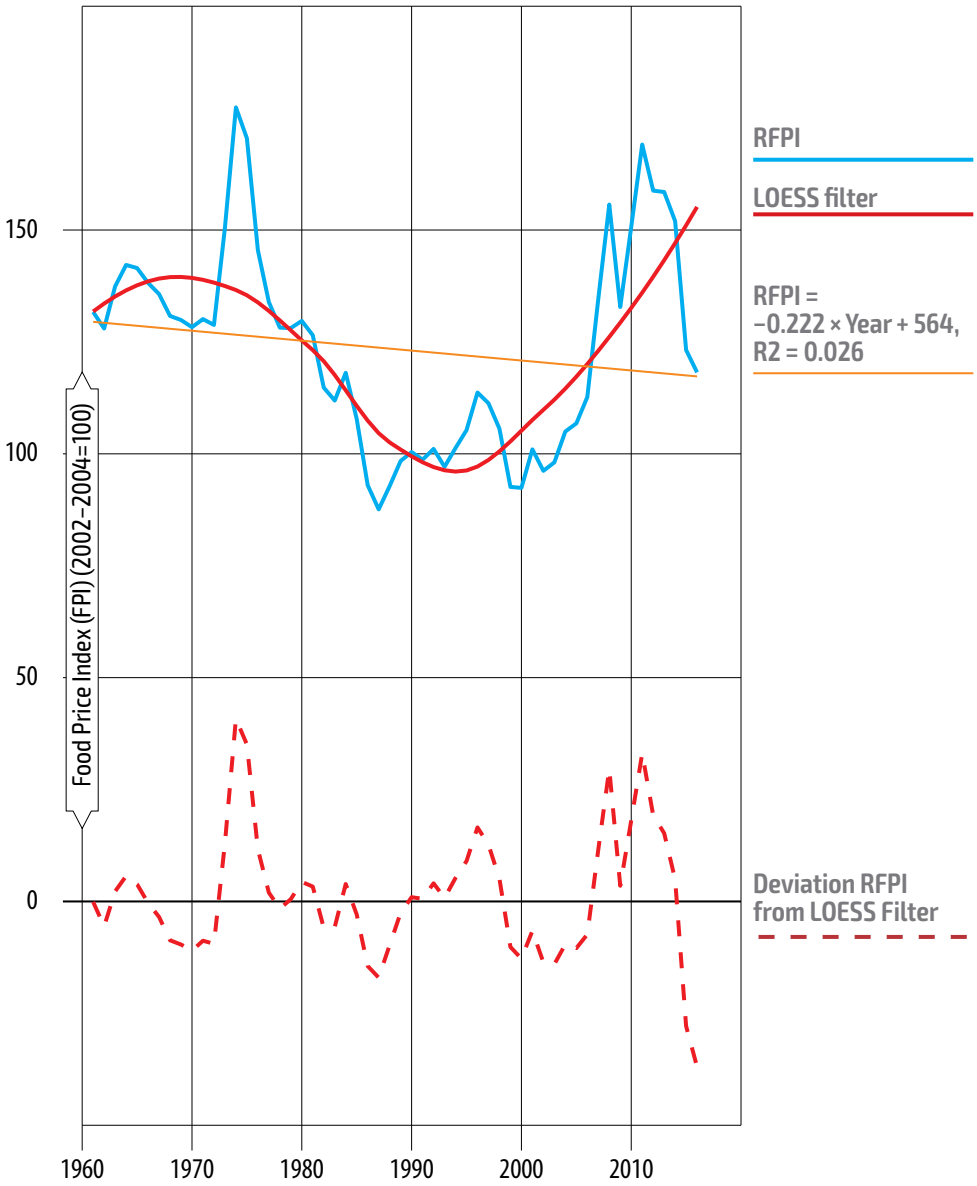
Despite the generally fast growth of agricultural trade, most of the food consumed in many countries is produced domestically; net imports are within the range of 0-20 percent of the domestic food supply in many instances (Figure 2.12). Some countries, such as Argentina, Australia and the United States of America, have net exports of more than 50 percent of their domestic food supply, while the Near East/North Africa region imports more than 50 percent of its food supply. Sub-Saharan Africa, South Asia and China are also net importers of food.

Figure 2.12 Percentage of net food imports in domestic food supply in total calories



Source: FAO Global Perspectives Studies, using 2011 food balance sheets from FAO, 2016a.

Figure 2.13 FAO real food price index (RFPI)



Note: The real food price index is the nominal food price index deflated with the manufactures unit value index as reported by the World Bank.

Source: FAO Global Perspectives Studies, based on FAO, 2016b.

Food prices have retreated to lower levels after peaking in 2011

After peaking in 2008 and again in 2011, FAO's real food price index[6] has fallen back to levels reached in the early 1980s, although it remains well above the low levels of the 1990s and early 2000s (Figure 2.13).

The most recent joint report by FAO and the Organisation for Economic Co-operation and Development (OECD) provides a somewhat mixed picture of medium-term developments in real food commodity prices to 2025. While the prices of meat and cereals, with the exception of coarse grains, are projected to decline in real terms, prices for dairy products will tend to rise over the next 10 years. While, in general, prices are projected to remain structurally higher than in the decade before the 2007–2008 price spike, such medium-term developments are 'not inconsistent with a very long-term trend for declining real prices' (OECD and FAO, 2016, p.53). This trend to lower prices for agricultural commodities is also reflected in the downward linear trend of FAO's real food price index (RFPI), although its statistical significance is less pronounced here than in the case of individual commodities, e.g. real wheat prices.

Food price fluctuations around the trend, and increased volatility and uncertainty, received substantial attention in the wake of the food price inflation crisis of 2007–08. Typical measures of volatility suggest that food price volatility in the last 50 years reached its highest level during the 1970s. However, the price fluctuations since 2000 have been above the levels observed in the previous decades (Díaz-Bonilla, 2016, p.41), when price levels were also below the linear trend line. When taking into account the drop in the FAO index in 2015 and 2016, it seems that volatility has continued to increase.[7] These deviations indicate levels of volatility approaching those observed during the 1970s.

Future levels of food prices depend, among other factors, on how production will be able to accommodate tightening resource constraints and climate change. Climate change may jeopardize the possibility of expanding agricultural yields in some regions of the globe, which is required to meet growing demand; the result would be upward pressure on prices (FAO, 2016c). In addition, mitigation policies may require the internalization of carbon-emission costs. Furthermore, prices in the long run may also rise, as long as there will be a need to reduce GHG emissions in order to comply with international agreements on climate change. However, adopting these mitigation measures would impose additional costs (at least in the short run), which would put upward pressure on output prices (Smith *et al.*, 2014).

[6] FAO's real food price index is estimated by aggregating the international prices of a basket of five groups of food commodities, weighted by the average export shares of each group for 2002–2004, and deflating the price of the composite food basket by the manufactures unit value index.

[7] Following the example of Diaz-Bonilla (2016), the RFPI series were 'de-trended' using a non-parametric filter (LOESS, red line in Figure 2.13) and the deviations of the RFPI from the smoothed series were calculated (dashed red line in Figure 2.13).

3 | Competition for natural resources

Projections to 2050 suggest the emergence of growing scarcities of natural resources for agriculture (Alexandratos and Bruinsma, 2012). Intensified competition for these resources could lead to their overexploitation and unsustainable use, degrading the environment and creating a destructive loop whereby resource degradation leads to ever increasing competition for the remaining available resources, triggering further degradation. For millions of farmers, foresters, pastoralists and fisherfolk, this could create insurmountable barriers to improving their livelihoods and escaping poverty.

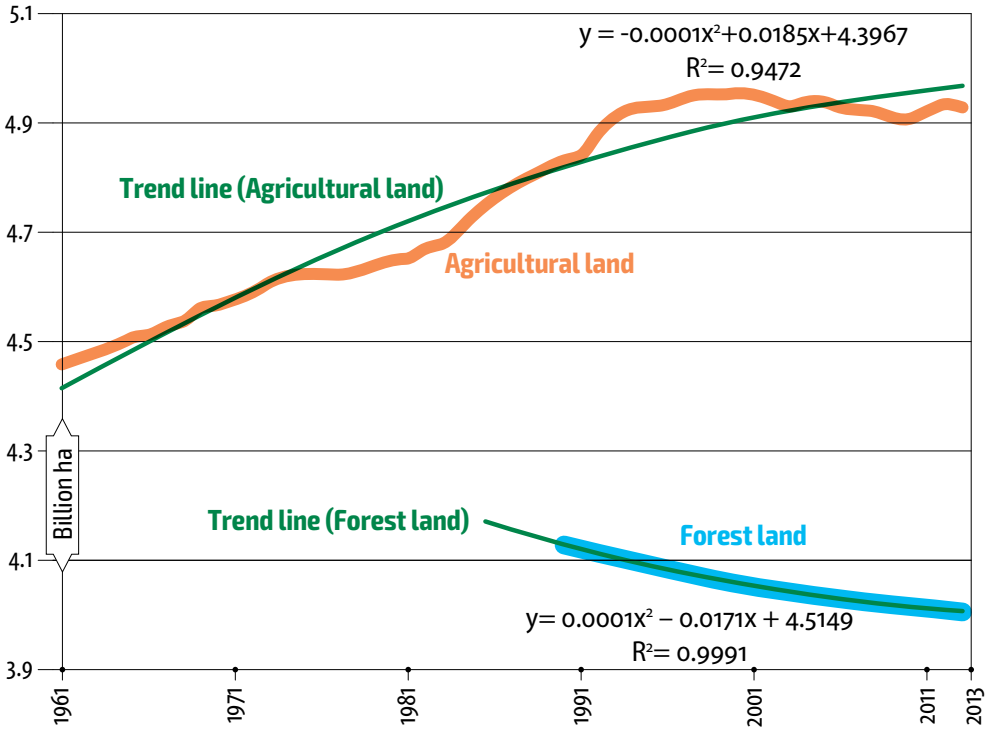
Although agriculture at the global level has become more efficient, in recent decades, competition for natural resources has intensified owing to consumption patterns driven mainly by population growth, changing dietary patterns, industrial development, urbanization and climate change. Land degradation, deforestation and water scarcities are among the most visible manifestations of this unsustainable competition. Paradoxically, some efforts aimed at reducing greenhouse gas (GHG) emissions have led to further intensification of competition for land and water resources. This is the case where countries have moved towards the production of resource-intensive bioenergy instead of choosing other available, and more sustainable, energy sources.

Globally, 33 percent of the world's farmland is moderately to highly degraded. This degradation affects particularly dryland areas, affecting the quality of local people's livelihoods and the long-term health of ecosystems. In general, land degradation is an impediment to realizing food security and reducing hunger. Globally, there are few opportunities left for further expanding the agricultural area. Moreover, much of the additional land available is not suitable for agriculture. Bringing that land into agricultural production would carry heavy environmental, social and economic costs (FAO, 2014).

The expansion of agricultural land continues to be the main driver of deforestation

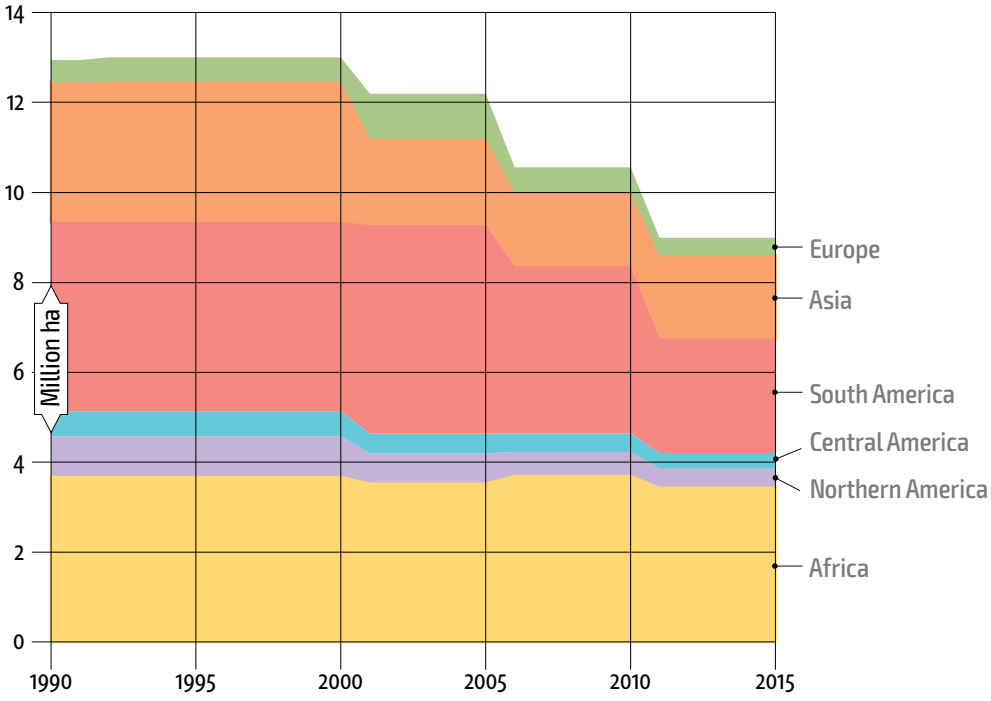
The global expansion of agricultural land has stabilized over the last 20 years at around 4.9 billion hectares (ha), while forest losses have amounted to less than 100 million ha (Figure 3.1). Globally, net forest conversion has been decreasing over the last 15 years (Figure 3.2), and annual losses have been reduced by 50 percent since 1990 (FAO, 2015). Projections indicate a need for less than 100 million ha of additional for agricultural use in 2050 (Alexandratos and Bruinsma, 2012).

Figure 3.1 Agricultural and forest land use 1961–2013



Source: FAO Global Perspectives Studies calculations based on FAO, 2016b.

Figure 3.2 Net forests conversion, by region, 1990–2015



Source: FAO, 2016b.

However, these global figures hide significant regional differences. Gains in forest areas have been limited to boreal and temperate zones, where the area under agriculture has declined. In tropical and subtropical regions, annual forest losses still amounted to 7 million ha between 2000 and 2010, while the agricultural area expanded in the same period by 6 million ha per year (FAO, 2016). Low-income countries experienced both the largest annual net loss of forest area and annual net gain in agricultural area.

Agriculture is estimated to be the proximate driver for around 80 percent of deforestation worldwide. Commercial agriculture is the most important driver of deforestation in Latin America, accounting for around two-thirds of total deforested area. In Africa and tropical and sub-tropical Asia, subsistence agriculture accounts for a larger share of deforestation than commercial agriculture (Kissinger, Herold and De Sy, 2012).

Clearing the land of forests leads to severe environmental degradation that can make the competition for other natural resources more acute among different users. For example, clearing forests in highland areas causes soil erosion, which reduces the quality of drinking water for downstream users and water used to sustain aquaculture. The loss of forestland owing to the expansion of commercial farms deprives forest communities, particularly the most impoverished forest communities, of plant and animal biodiversity that is often critical to their food security. The loss of forest biodiversity also has repercussions for global food security, as it reduces options for breeding new crops and plant varieties that may allow food systems to better adapt to climate change. Deforestation also is a major source of GHG emissions.

Pressure to clear forests is expected to grow owing to urbanization and changing patterns of consumption driven by population growth, migration, greater prosperity, expanding commodity markets and climate change adaptation. However, there is evidence that it is possible to reconcile food security and forest conservation. Twenty-two countries – or around half of all countries that, by FAO estimates, have reduced both the number and the prevalence of undernourished people (FAO, IFAD and WFP, 2013) – have improved agricultural production and food security in the past 25 years, while maintaining or increasing their forest cover (FAO, 2016). Their achievement is due to the simultaneous implementation of policies to promote the intensification of agricultural production, the sustainable management of forest resources and other measures that improve food security.

Competition for natural resources is increasing as countries search for bioenergy alternatives to fossil fuels

Currently around 14 percent of all energy used globally comes from renewable sources. Around 73 percent of that comes from bioenergy, including liquid transportation fuels and the combustion of municipal solid waste and woodfuel. Projected demand for bioenergy in electricity generation indicates growth of 50 percent between 2013 and 2020, while bioenergy for heating purposes is projected to grow by approximately 25 percent (IEA, 2016). The consumption of cereals and oilseeds for the production of biofuels has increased, as has the use of biomass as a substitute for petrochemicals.

This shift to bioenergy has implications for agriculture and food production. For example, in aquaculture, which provides more than

50 percent of all fish consumed, oilseeds are becoming a major component of fish feed, and demand for oilseeds will expand as aquaculture production methods continue to intensify.

Around two-thirds of the bioenergy used worldwide involves the traditional burning of wood and other biomass for cooking and heating in low-income countries. As populations expand in these countries, it is expected that the use of these sources of bioenergy will also increase. Much of this traditional wood energy is unsustainably produced and inefficiently burned, affecting the health of poor populations and contributing to environmental degradation. At the global level, the use of woodfuel is not seen as major contributor to deforestation and forest degradation, but in areas near urban centres, the demand for wood and charcoal for domestic needs is a serious environmental problem (FAO, 2011a).

In recent years, there has been a significant increase in the production of biofuels, from around 60 billion litres in 2007 to around 130 billion litres in 2015. Output is projected to grow to 140 billion litres in 2020 (IEA, 2016), with a corresponding impact on the production and consumption of food and feed crops. For example, between 2000 and 2011, world cereal consumption increased at a rate of 1.8 percent a year. Almost one-third of that annual increase went towards biofuel production in the United States of America alone.

There has also been an increased use of vegetable oil for biofuel production. Between 2000 and 2009, the consumption of vegetable oil for all purposes grew at an annual rate of 5.1 percent, while the consumption of vegetable oil for biofuel production grew at an annual rate of 23 percent (HLPE, 2011). Projections indicate that by 2024, one-quarter of sugarcane production will be used for the manufacturing of ethanol, a 21 percent increase from 2014 (OECD and FAO, 2015). The increase in production of these bioenergy crops has led to a conversion of considerable areas of forest into farmland.

Growing international trade in wood pellets as fuel is another recent trend that could have an impact on the competition for land. Although there have been concerns that the expanding demand for industrial wood energy in industrialized countries would lead to an expansion of trade in this area from low-income countries, this situation has not yet materialized (UNECE and FAO, 2016). However, it is important to note that new investments have been made in expanding tree plantations in developing countries, with a view to supplying demand in industrialized countries for wood energy.

The greater competition between food and non-food uses of biomass has increased the interdependence between food, feed and energy markets. There are risks that this competition may also have harmful impacts on local food security and access to land resources. Input subsidies, on energy, fertilizers, and water, as well as public purchases of agricultural produce may add unintended additional pressure on natural resources. In the fisheries sector, subsidies contribute to overcapacity of global fishing fleets, which results in overfishing. Subsidies are often designed to promote production and food security, but may also promote the expansion of agricultural lands. The overall impact of rising demand for biomass will depend on productivity

improvements in the agricultural sectors and good practices in sustainable bioenergy.[1]

Depending on the supply of land, and the extent to which intensification is labour- or capital- intensive, there is a risk that agricultural intensification may lead to more cropland expansion rather than less. In addition, mitigating climate change by mandating the use of biofuels in one region may increase global GHG emissions due to indirect land-use changes in locations where the biofuel feedstock is grown (Lambin and Meyfroidt, 2011).

The risks and opportunities associated with increased bioenergy production will also be magnified by the global shift toward an economy geared to biomass-based goods. The World Economic Forum estimates that, globally, the revenue potential for new business opportunities in the biomass value chain could amount to about US$295 billion by 2020, which is three times its 2010 value (World Economic Forum, 2010). The importance and challenges of sustainable bio-economy development and its transformative role of the agriculture, forestry and fisheries sectors, were recognized at the 2015 meeting of the Global Forum for Food and Agriculture, which gave FAO the mandate to coordinate international work on a 'food-first' bio-economy (GFFA, 2015).

Recent work by FAO and other organizations has shown that there are a number of good practices that can accommodate the sustainable production of food, bio-based products and bioenergy, including biofuels. They include agro-ecological zoning and complementing the production of food with bioenergy generation through sustainable agriculture intensification. There is also good potential for developing integrated food-energy systems that optimize land use, such as mixed food and energy crop systems, and increasing the use of biomass for energy (e.g. biogas from livestock manure).

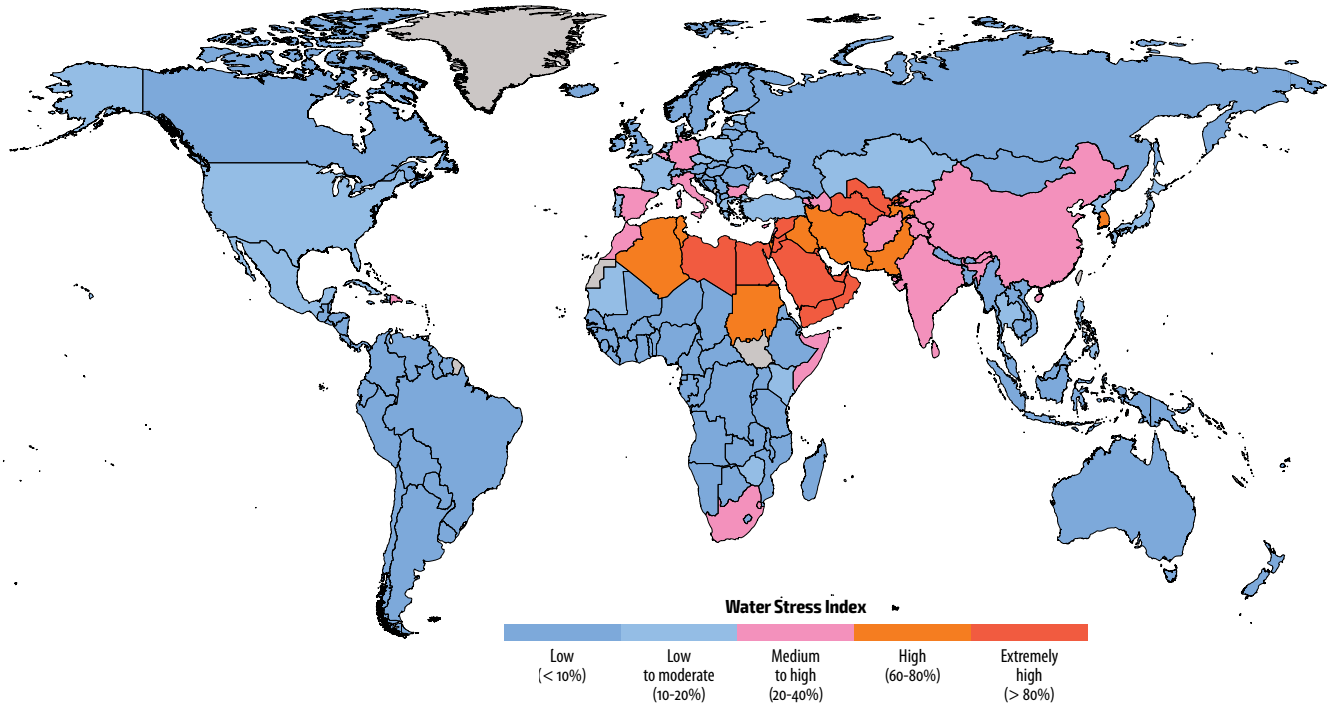
[1] In 2015, 0.6 ha of forests per person were used to sustain demand for food, land and fuel. See FAO, 2015.

As a result of competing demands from agriculture, industry and cities, major river basins now face water scarcity

Countries may be considered water-stressed if they withdraw more than 25 percent of their renewable freshwater resources. They approach physical water scarcity when more than 60 percent is withdrawn, and face severe physical water scarcity when more than 75 percent is withdrawn (FAO, 2016a).

Water withdrawals for agriculture represent 70 percent of all withdrawals. FAO estimates that more than 40 percent of the world's rural population lives in river basins that are classified as water scarce (FAO, 2011b). In many low-rainfall areas of the Middle East, North Africa and Central Asia, and in India and China, farmers use much of the available water resources, resulting in the serious depletion of rivers and aquifers (Figure 3.3). In some of these areas, about 80 to 90 percent of the water is used for agricultural purposes. The intensive agricultural economies of Asia use about 20 percent of their internal renewable freshwater resources, while much of Latin America and sub-Saharan Africa, in contrast, use only a very small percentage.

Figure 3.3 Freshwater withdrawals as a percentage of total renewable resources



Source: FAO, 2016a.

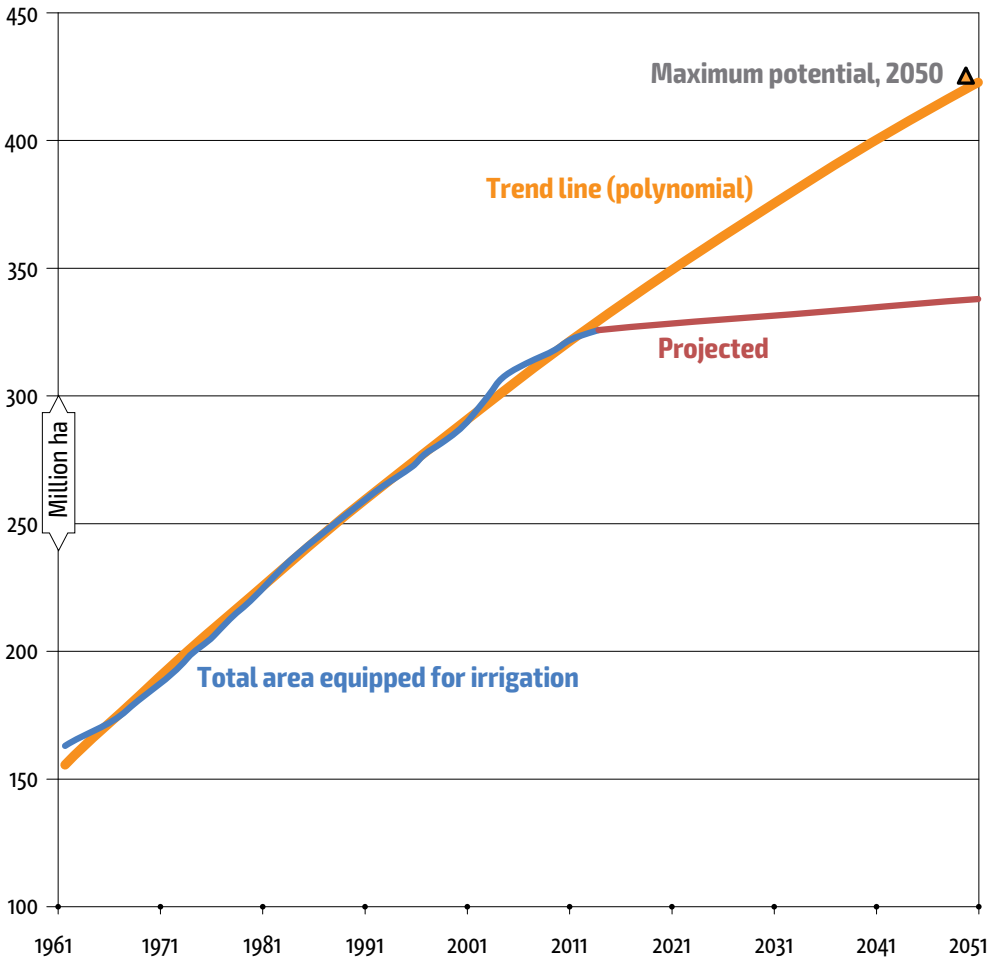
Given these constraints, the rate of expansion of land under irrigation is slowing substantially. FAO has projected that the global area equipped for irrigation may increase at a relatively low annual rate of 0.1 percent.[2] At that rate, it would reach 337 million ha in 2050, compared to around 325 million ha in 2013 (Figure 3.4). This represents a significant slowdown from the period between 1961 and 2009, when the area under irrigation grew at an annual rate of 1.6 percent globally and more than 2 percent in the poorest countries. Most of the future expansion of irrigated land is projected to take place in low-income countries.

Growth in agricultural water use is decelerating, partly owing to the improved performance of irrigation systems and agricultural practices. However, with rapid urbanization, the demand for water is becoming more and more spatially concentrated. Competition for water, and the construction of dams and diversions that interfere with fish migration, can have also a major impact on inland fisheries. While allocations of water are shifting away from agriculture to meet the needs of urban users, there is still room for improving these allocations in both economic and environmental terms. In this regard, finding non-competing uses of water resources, such as using treated urban wastewater for irrigating crops, will become increasingly important. There may be some scope to further exploit water resources, such as rivers and lakes, to increase food production through the development of inland aquaculture.

It is expected that aquaculture will continue to expand in the decades ahead through intensification, species diversification, expansion into new areas (such as offshore marine waters), and the introduction of innovative, more resource-efficient technologies. Thanks to these improvements, output

[2] FAO Global Perspectives Studies, based on Alexandratos and Bruinsma, 2012.

Figure 3.4 Trends and projections in total land equipped for irrigation to 2050



Sources: Years 1961–2013 from FAO, 2016b; annual growth rate of projections 2014–2050 (0.1%) and maximum potential to 2050 from Alexandratos and Bruinsma, 2012.

from aquaculture – having become the major source of fish for human consumption in 2014 – is expected to overtake total output from capture fisheries by 2021 (OECD and FAO, 2016). However, water scarcity, competition from other users and environmental degradation all have negative impacts on aquaculture production.[3] A diversification of global food production that includes aquaculture offers enhanced resilience, but its promise will not be realized if government policies fail to provide incentives for resource-use efficiency, equity and environmental protection (Troell *et al.*, 2014).

Finally, pressure on natural resources will be driven not only by changes in demand, but by changes in climate. Rainfall and temperatures are projected to become more variable with climate change, which will lead to a higher incidence of droughts. This will have particularly heavy impacts on rainfed smallholder farming systems in highland areas and in the tropics, which account for 80 percent of the world's cropland and produce about 60 percent of global agricultural output (FAO, 2011b).

[3] Other factors that can affect the further growth of aquaculture include: capital constraints, governance challenges and regulatory framework, feed and seed (eggs, spawn, fry, larvae, spat, fingerlings, etc.) supply, genetic resources, environmental integrity and disease problems, development and adoption of new and improved farming technologies, market, trade and food safety, climate change and investment capital impediments and problems that can originate from unguided and unmonitored aquaculture practices.

4 | Climate change

According to the most recent assessment report of the Intergovernmental Panel on Climate Change (IPCC), published in 2014, levels of anthropogenic emissions of greenhouse gases (GHGs) are now at their highest in history (Porter *et al.*, 2014). Agricultural production and its effect on land use are major sources of these emissions. Charting environmentally sustainable pathways for agricultural development has a central role to play, therefore, in mitigating climate change.

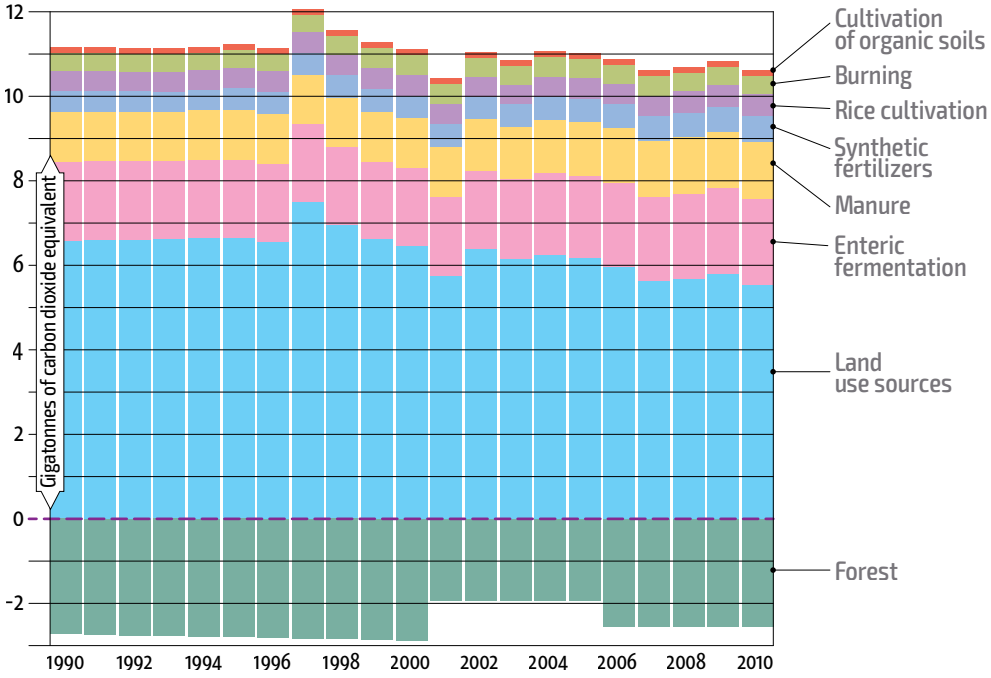
The impacts of climate change are expected to be most adverse in low- and middle-income countries, where millions of people depend on agriculture and are vulnerable to food insecurity. In 2015, world leaders explicitly acknowledged the need to address this threat. They negotiated, under the aegis of the United Nations Framework Convention on Climate Change (UNFCCC), the Paris Agreement on climate change, which recognizes 'the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse effects of climate change' (UNFCCC, 2015).

Food and agriculture sectors contribute substantially to greenhouse gas emissions, but mitigation options exist

Over the past 50 years, greenhouse gas (GHG) emissions resulting from 'Agriculture, Forestry and Other Land Use' (AFOLU) have nearly doubled, and projections suggest a further increase by 2050 (Tubiello *et al.*, 2014). In 2010, emissions from the AFOLU sector were an estimated 10.6 gigatonnes (Gt) of carbon dioxide equivalent, and were mainly caused by land use, livestock production, and soil and nutrient management (Figure 4.1). The sector produces an estimated 21 percent of total global GHG emissions (FAO, 2016e, Fig.2). However, forests also mitigate climate change by removing GHG from the atmosphere through biomass growth. The average contribution of forests to carbon sequestration was around 2 Gt a year since the turn of the century. This implies that the annual net emissions of AFOLU were slightly above 8 Gt (Figures 4.1 and 4.2).

Agriculture contributes the largest share of global methane and nitrous oxide emissions. Most of its methane emissions is produced by enteric fermentation during the digestive processes of ruminant animals, and by rice cultivation. The nitrous oxide emissions originate mainly from the application of nitrogen-based fertilizers and animal manure management. The removal of GHG by forests has fallen from 2.8 Gt annually in the 1990s to an estimated 1.8 Gt in 2014 (FAO, 2016e, p.38). The decline is believed to be linked to increasing variability in climate and atmospheric composition. A 2016 study of biomass dynamics in the Amazon rainforest over three decades found that the region is losing its ability to sequester carbon dioxide owing to an increasing rate of biomass mortality (Brienen *et al.*, 2016).

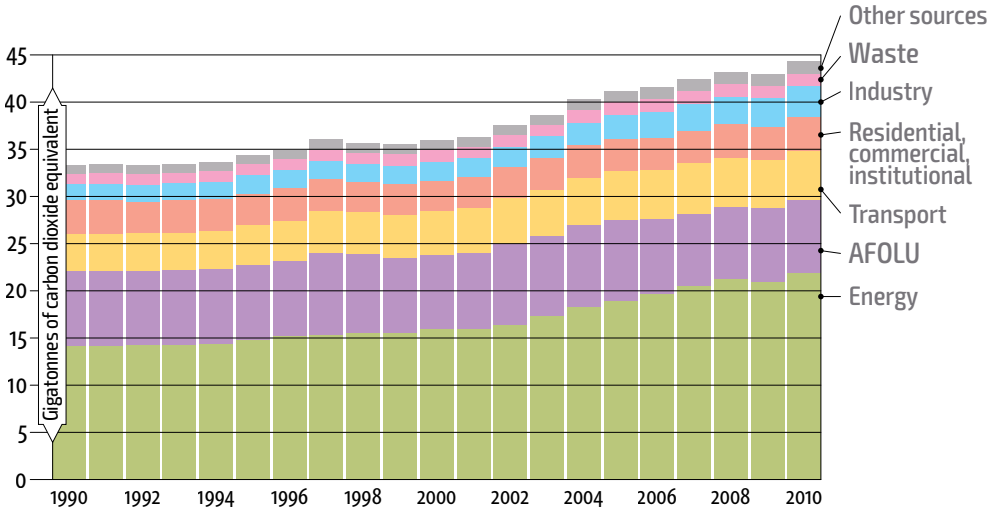
Figure 4.1 **Annual greenhouse gas emissions from Agriculture, Forestry and Other Land Use (AFOLU)**



Note: The classification of emissions is according to FAO, 2016c. 'Manure' includes 'manure left on pasture', 'manure management' and 'manure applied to soils'; 'Burning' includes 'burning – crop residues', 'burning – savanna' and 'crop residues'.

Source: FAO, 2016c (Metadata/emissions – agriculture).

Figure 4.2 **Annual greenhouse gas emissions from all sectors**



Note: 'Other sources' includes international bunkers.

Source: FAO, 2016b.

Emissions produced by the use of energy in primary agriculture (e.g. fuel for tractors) are not included in the IPCC's AFOLU classification. If they are taken into account, emissions from the sector rise by a further 0.9 Gt (FAO, 2016c). If GHG emissions resulting from energy use in processing, trade and consumption of food (approximately 3.4 Gt) are also considered, the total amount of net GHG emissions from the food and agriculture sector would amount to 12.3 Gt, or around 26 percent of total GHG emissions (FAO, 2011).

Climate change mitigation in agriculture involves shifting to agricultural practices that increase food production in ways that are that are less 'GHG intensive', i.e. release fewer GHG emissions per unit of food. Many such practices exist – for example, improving cattle feed so that it produces fewer emissions from enteric fermentation, and intensifying production so that more food can be produced from fewer animals. Alternate wetting and drying is a water-saving practice that can reduce water use in rice cultivation by 15-25 percent without affecting yields and lower methane emissions by 30-70 percent (FAO, 2013b).

In the IPCC's Fifth Assessment Report, a whole chapter was dedicated to food security and food production systems, while in the previous report they were included in a chapter on 'food, fibre, and forest products'. This is a clear indication of the growing recognition of the importance of agriculture to global efforts to address climate change.[1] The Paris Agreement also reaffirmed the importance of reducing GHG emissions from deforestation and forest degradation, and encouraged countries to take action in this area.

[1] Chapters in the IPCC Fifth Assessment Report are also devoted to freshwater resources, terrestrial and inland water systems, coastal and ocean systems. Reducing vulnerabilities and increasing resilience and adaptation in all of these ecosystems will have benefits to food security and rural livelihoods.

Climate change will affect every aspect of food production

In its latest assessment, the IPCC has stated with high confidence that in low-latitude countries crop production will be 'consistently and negatively affected by climate change'. In northern latitudes, the impacts on production are more uncertain; there may be positive or negative consequences (Porter *et al.*, 2014). Increasing variability of precipitation and increases in the frequency of droughts and floods are likely to reduce yields in general. Although higher temperatures can improve crop growth, studies have documented that crop yields decline significantly when daytime temperatures exceed a certain crop-specific level (FAO, 2016e). The IPCC assessment report has stated with medium confidence that climate change will increase the interannual variability of crop yields in many regions. The use of climate models in conjunction with crop models is contributing valuable insights into the possible impacts of climate change on yields. For the main cereals, projected yields, due to climate change under the different representative concentration pathways show significant regional increases and decreases but mostly downward shifts globally (FAO, 2016e).

A meta-analysis of 1090 studies on yields (primarily wheat, maize, rice and soybeans) under different climate change conditions indicates that climate change may significantly reduce yields in the long run (Figure 4.3). Further analysis by FAO found quite distinct patterns for low- and middle-income countries in tropical areas, and high-income countries in temperate zones. For the former, most estimates for crop yield impacts are negative, with the share of negative estimates increasing the further into

the future the study projects. Compared with those outcomes, estimates for high-income countries showed a much larger share of potentially positive changes (FAO, 2016e).

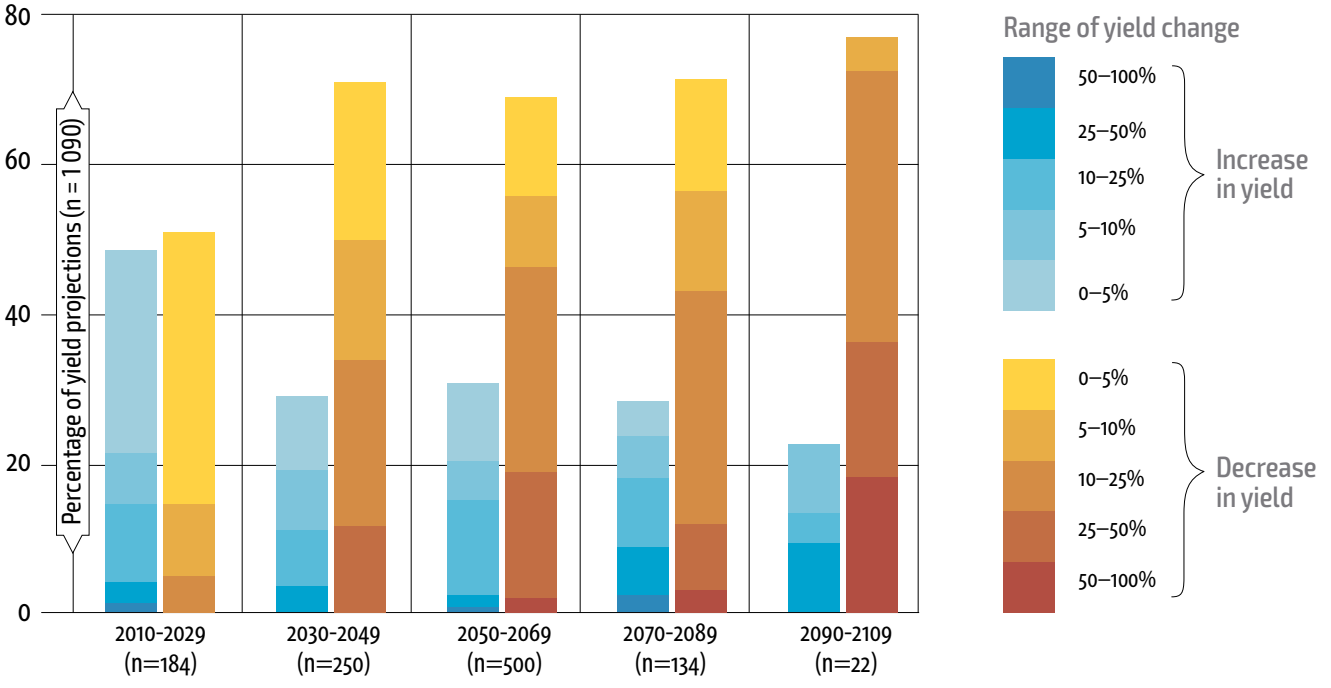
However, significant knowledge gaps remain about the impacts of climate change. Future research needs to pay closer attention, for example, to the impact of yield variability on the quantity and quality of food production. More refined investigations of the impacts of climate change on agriculture, through changes in temperature, rainfall, humidity and other factors under different climate scenarios, could be made easier with the release of a new version of the FAO-IIASA Global Agro-Ecological Zones system, which develops assessments on the world's agricultural and natural resources potentials.[2]

[2] For more information, see IIASA, 2015.

Higher temperatures and less reliable supplies of water will also create severe hardships for small-scale livestock producers, particularly in arid and semi-arid grassland and rangeland ecosystems at low latitudes (Hoffman and Vogel, 2008). Heat and water scarcity will have a direct impact on animal health and will also reduce the quality and supply of feed and fodder (FAO, 2009). There is some evidence that global warming has already affected the distribution of some marine fish species, with warm-water species shifting towards the poles (FAO, 2013a). One modelling exercise has projected that the catch potential in tropical countries could decline by 40 percent, while in high-latitude waters the potential could increase by between 30 and 70 percent (Cheung *et al.*, 2009). Changes in temperature and rainfall will also cause the distribution of inland fish species to shift.

The IPCC report stated with high confidence that in low-latitude regions, temperature increases of 3°C will cause local extinctions of some fish

Figure 4.3 Projected changes in crop yields owing to climate change



Source: Porter *et al.*, 2014, p.504.

species at the edges of their ranges. Both gradual atmospheric warming and associated physical changes (sea surface temperature, ocean circulation, waves and storm systems), and chemical changes (salinity content, oxygen concentration and acidification), have impacts in aquatic environments (IPCC, 2013). Rising sea levels will threaten coastal aquaculture production in river deltas and estuaries. Higher levels of carbon dioxide in the atmosphere are making the oceans more acidic, reducing the ability of important aquaculture species (e.g. mussels, clams and oysters) to form and maintain shells and slowing down or even preventing the growth of coral reefs, which provide an important habitat for fish (IGBP, IOC and SCOR, 2013). These changes can have a major impact on small-scale fishers using traditional methods, with a consequent impact on food security. Furthermore, extreme weather events and sea level rise will damage fisheries infrastructure, such as ports and fleets, further raising the costs of fishing, processing and distribution (OECD and FAO, 2016).

Current forecasts of changes in the distribution and productivity of marine fish species and communities are typically at a global or regional scale. Increasing the resolution to allow for the forecasting of impacts at the national and local ecosystem scale would provide valuable information to governments and stakeholders. It would enable them to prepare more effectively for expected impacts on food production and security (FAO, 2016a).[3] The IPCC has projected that global warming between 1 and 2°C will have a moderate impact on the planet's biodiversity (Porter *et al.*, 2014). For agricultural ecosystems, there is evidence that some crops species and varieties currently grown in a particular area may not be able to adapt quickly enough to the changes. Because different species will react differently, the complex interactions among species will be disrupted, potentially affecting ecosystem services such as pollination and the control of crop pests by natural predators. Plant and animal pests and diseases may spread into areas where they were unknown before, but important knowledge gaps remain in this area (Porter *et al.*, 2014). Climate change will also contribute to existing long-term environmental problems, such as groundwater depletion and soil degradation, which will affect food and agriculture production systems.

[3] Shifts in resource availability will require vulnerable communities to adapt their consumption patterns to new aquatic species to replace commercial species as they move to deeper cooler waters off continental shelves and into northern latitudes. Fishing communities and small-scale fisherfolk are at particular risk, owing to the danger posed to ocean fishing by severe weather episodes and the inadequacy of artisanal vessels. As sea levels rise, Small Island Developing States (SIDS) are facing the reality of shrinking coastlines and Exclusive Economic Zones, further depleting their available resources. Aquaculture producers face higher incidence of disease owing to climate change, as well as risk of stocks escaping from ponds during severe weather episodes.

Without efforts to adapt to climate change, food insecurity will likely increase substantially

In its 2014 report, the IPCC reviewed various models that estimated the impact of climate change on undernutrition and concluded with high confidence that climate change will have a 'substantial negative impact' on per capita calorie availability, childhood undernutrition, and child deaths related to undernutrition in low- and middle-income countries (Porter *et al.*, 2014). In its previous report, the IPCC concluded with high confidence that increases in the frequency and severity of extreme climate events, such as heat waves, droughts, floods, tropical storms and wildfires, will have greater consequences agricultural production and food insecurity than higher temperatures and more erratic rainfall (IPCC, 2007).

Climate change's impact on global food security will relate not just to food supply, but also to food quality, food access and utilization, and

the stability of food security. Climate change may affect the nutritional properties of some crops. Research has found that under conditions of elevated levels of carbon dioxide, the concentrations of minerals in some crops (e.g. wheat, rice and soybeans) can be up to 8 percent lower than normal. Protein concentrations may also be lower, while carbohydrates are higher (FAO, 2015). Climate change is also expected to increase the incidence of diseases, particularly water–borne diseases, such as diarrhoea, that contribute to undermining the body's ability to utilize the nutrition in food. Higher temperatures and less rainfall will make clean water less available in many areas, compromising hygiene, and facilitating spread of water-borne pathogens. A World Health Organization (WHO) assessment estimates that in the future (2030–2050) climate change will cause an additional 48 000 deaths per year from diarrhoea (WHO, 2015).

The IPCC has concluded with medium confidence that the projected changes in temperature and precipitation on food production will contribute to an increase in global food prices by 2050 (Porter *et al.*, 2014). Higher food prices could reduce vulnerable people's access to food. There have been several periods of rapid food and cereal price increases following climate extremes in key producing regions. Due to its potential impacts on production, climate change may also reduce the earnings of producers practicing small-scale and subsistence agriculture, further threatening their ability to obtain food.

The adoption of sustainable practices by smallholders will be crucial to climate change adaptation efforts

The IPCC is moderately confident that agronomic adaptation can improve yields by the equivalent of 15 to 18 percent. However, the effectiveness of adaptation varies by context. Specific social and environmental conditions will influence smallholders' choice of adaptation measures. It is important to note that current adaptation measures to improve yields may have different impacts as the climate changes. For example, the application of mineral fertilizer may generate higher yields under average climatic conditions, but may bring lower yields when rainfall is highly variable or delayed. Similarly, crop rotation may produce lower yields under average climatic conditions, but produce higher yields when there is high rainfall variability (Arslan *et al.*, 2015).

Future research should examine the impact of proposed adaptations under current climatic conditions, so that management changes that are beneficial in a range of environments can be separated from management changes that are specifically targeted at climate change. Studies of the adaptation of cropping systems typically only assess relatively minor agronomic management changes under future climate conditions, but adaptation to extremes is also crucial. In livestock systems, adaptation measures could include using breeds better suited to the prevailing climate.

The adoption of sustainable land, water, fisheries and forestry management practices by smallholder agricultural producers will be crucial to efforts to adapt to climate change, eradicate global poverty and end hunger. Such practices could yield significant productivity improvements (FAO, 2016d). However, in order to encourage adoption, improvements will also

be necessary in infrastructure, extension, climate information, access to credit, and social insurance – conditions which are at the heart of rural development (FAO, 2016e). In many cases, impoverished, food insecure farmers, pastoralists and fishers simply may not have the assets needed to make significant changes in their production methods. Overcoming these barriers to adoption require effective social protection systems. Such systems, which have been put in place in more than 100 countries, have become an important tool for reducing hunger. It is estimated that they have prevented 150 million people worldwide from falling into extreme poverty (Fiszbein, Kanbur and Yemtsov, 2014).

The latest IPCC assessment also makes clear that climate change will exacerbate existing gender inequalities. This will be particularly true in impoverished agricultural communities where food insecurity is already severe. Women farmers make up more than half of the agricultural workforce in some low- and middle-income countries and, in that role, play a crucial part in managing natural resources. They are systematically disadvantaged compared to men, with fewer endowments and entitlements and more limited access to information and services. Their household responsibilities are gender-determined and they shoulder increasingly heavy agricultural workloads owing to male out-migration (FAO, 2016e). To date, climate change research has placed little emphasis on understanding the different adaptive strategies of men and women (CGIAR, CCAFS and FAO, 2011).

Finally, to safeguard food security, measures for climate change adaptation need to be applied not only to food production, but also to all other stages of the food supply chain. However, as of yet, there has not been sufficient research into the impacts of climate change on food processing, packaging, transport, storage and trade. Adaptation initiatives need to engage multiple sectors and consider a broad range of systemic and transformational options (Porter *et al.*, 2014).

5 | Agricultural productivity and innovation

To meet demand, agriculture in 2050 will need to produce almost 50 percent more food, feed and biofuel than it did in 2012. This FAO estimate takes into account recent United Nations (UN) projections indicating that the world's population would reach 9.73 billion in 2050.[1] In sub-Saharan Africa and South Asia, agricultural output would need to more than double by 2050 to meet increased demand, while in the rest of the world the projected increase would be about one-third above current levels (Table 5.1).

Table 5.1 Increase in agricultural production required to match projected demand, 2005–2050 (percent)

	2005/07	2050	2005/07 2012	2013-2050
World				
As projected in AT2050	100	159.6	14.8	44.8
With updated population projections (UN, 2015)	100	163.4	14.8	48.6
Sub-Saharan Africa and South Asia				
As projected in AT2050	100	224.9	20.0	104.9
With updated population projections (UN, 2015)	100	232.4	20.0	112.4
Rest of the world				
As projected in AT2050	100	144.9	13.8	31.2
With updated population projections (UN, 2015)	100	147.9	13.8	34.2

Source: FAO Global Perspectives Studies, based on UN, 2015, and Alexandratos and Bruinsma, 2012.

[1] The estimated increase to 2050 differs from AT2050's projection of an increase of 60 percent (Alexandratos and Bruinsma, 2012). The updated figure here accounts for both the UN's revised population projection and increases in production between 2005/07 (the previous base year) and 2012 (the new base year). Accounting only for the revised population projections, global agricultural demand is projected to increase by more than 63 percent between 2005/07 and 2050. Since production expanded by 15 percent between 2005/07 and 2012, the projected increase in agricultural demand from 2013 to 2050 would amount to approximately 49 percent.

Meeting the increased demand should not be a major challenge, if past achievements are a guide. Historically, much bigger increases in agricultural production have been recorded in comparable time frames. Between 1961 and 2011, global agricultural output more than tripled. In low-income countries, livestock production has been one of the fastest growing agricultural subsectors. Since the early 1970s, per capita consumption of milk, dairy products and vegetable oils has almost doubled, while meat consumption has almost tripled (Alexandratos and Bruinsma, 2012).

Over the past five decades, per capita consumption of fish has more than doubled. Since the 1980s, virtually all of the increase in the amount of fish consumed has come from aquaculture, which has outpaced population

growth and become the world's fastest growing food production industry (FAO, 2016c).

However, owing to a range of factors, including climate change, pressure on natural resources, underinvestment in agriculture and gaps in technology, maintaining the pace of production increases may be more difficult than in the past. For example, per capita fish consumption in Africa may shrink from 7.5 kg a year in 2006 to 5.6 kg a year by 2030, as the population is expected to grow more rapidly than supply (WFP, 2013, p. 45). Rapid technological development and innovation offers the prospect of meeting future food needs sustainably. However, this can only be achieved through discerning public policies, increased investments and public-private partnerships, which exploit the opportunities for maintaining current levels of productivity, sustainably raising yields, and reducing poverty and food insecurity.

Yield increases are slowing, despite overall improvements in agricultural efficiency

Increased use of land, irrigation and agro-chemicals played a major role in the growth of agricultural production during the Green Revolution. However, it is now recognized that the gains were often accompanied by negative effects on agriculture's natural resource base, including land degradation, salinization of irrigated areas, over-extraction of groundwater, the build-up of pest resistance and the erosion of biodiversity. Agriculture has also damaged the wider environment through deforestation, the emission of greenhouse gases and nitrate pollution of water bodies (FAO, 2011a).

Since the 1990s, average annual increases in the yields of maize, rice, and wheat at the global level have been slightly more than 1 percent, much lower than in the 1960s (Figure 5.1), while those of soybeans and sugarcane have been below 1 percent. Because the substantial additional amounts of food needed in coming decades will be produced mainly through yield increases, rather than major expansion of the cultivated area, cereal yield growth rates below 1 percent a year would be a worrying signal.[2] There are also very large differences in crop yields between high-income and low-income countries (Table 5.2). Yields of wheat and rice in low-income countries are currently about half those in high-income countries.

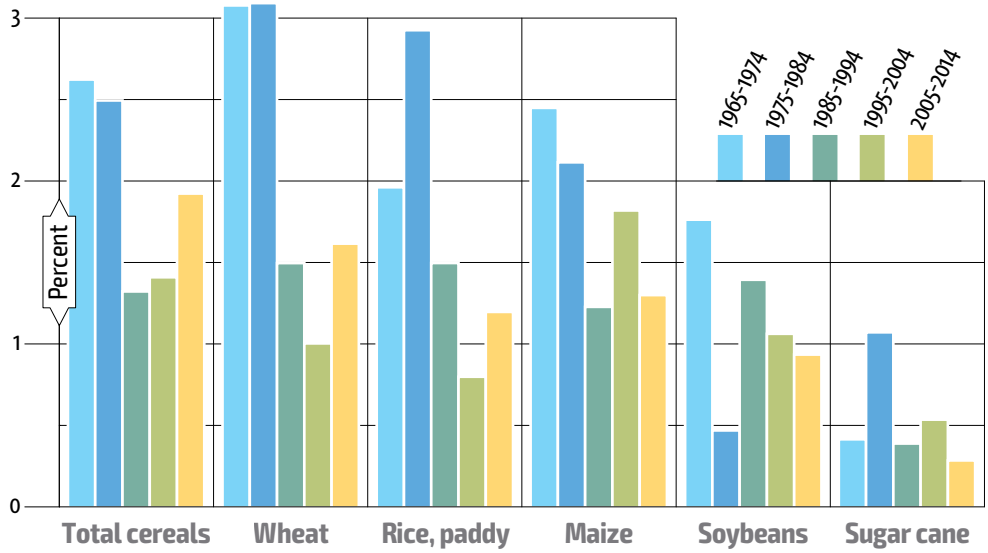
[2] Cereal production would need to increase from 2.068 billion tonnes in 2005–07 to 3.009 in 2050, a 43.4 percent increase (Alexandratos and Bruinsma, 2012). The assumption that 80 percent of this increase should come from yield increases implies that yields should increase by around 35 percent by 2050, i.e. in 34 years. This translates into an annual growth rate of 0.9 percent.

Table 5.2 Annual average crop yields, 2001–2012 (tonnes/ha)

Country group	Wheat	Rice	Maize
Low-income	1.82	3.3	1.54
Lower middle-income	2.74	3.65	2.74
Upper middle-income	2.67	5.28	4.41
High-income	3.5	6.64	8.99
World	2.92	4.16	4.87

Note: Country groupings are the same as those used by the World Bank, 2012.
Source: FAO, 2014.

Figure 5.1 Average annual growth rates for selected crop yields



Note: Calculations based on FAOSTAT production statistics (downloaded on 20 September 2016). Growth rates estimated using the ordinary least squares (OLS) regression of the natural logarithm of crop yields on time and a constant term. The commodity group 'Cereals (total)' is from FAOSTAT and includes: wheat, rice (paddy), barley, maize, rye oats, millet, sorghum, buckwheat, quinoa, fonio, triticale, canary seed, as well as grains and mixed cereals not elsewhere specified.

Source: FAO, 2016b.

Yields of major crops (cereals, roots and tubers, pulses, sugar crops, oil crops and vegetables) also vary substantially across regions. Estimated yield gaps, expressed as a percentage of potential yields, exceed 50 percent in most low-income countries. They are largest in sub-Saharan Africa (76 percent) and lowest in East Asia (11 percent). The gap between farm yields and potential yields reflects constraints, such as insufficient adoption of more productive technologies, a lack of market integration and gender inequalities in small-scale family farming (FAO, 2011b).

The productivity of aquaculture has been increasing, owing to the intensification of production methods. In Asia, small-scale traditional pond aquaculture, in which a range of carp species with complementary feeding behaviours were stocked in fertilized ponds, has given way to farmed fish and crustacean production that is heavily, if not exclusively, reliant on feeds. Key drivers have been rising land prices and the high prices paid for farmed fish, which makes feeds affordable (Beveridge *et al.*, 2013).

Resource-conserving practices are helping to increase agricultural productivity

The key to sustainable agricultural growth is more efficient use of land, labour and other inputs through technological progress, social innovation and new business models. For agriculture and aquaculture to respond to future challenges, innovation will not only need to improve the efficiency with which inputs are turned into outputs, but also conserve scarce natural resources and reduce waste (OECD, 2011; Troell *et al.*, 2014). The farming practices required to conserve and make more efficient use of natural resources will differ according to local conditions and needs.

Recent years have seen a growing trend towards the adoption of conservation agriculture. This approach seeks to reduce soil disturbance by

minimizing mechanical tillage, maintain a protective organic cover on the soil surface, and cultivate a wider range of plant species – both annuals and perennials – in associations, sequences and rotations that may include trees, shrubs, pastures and crops. It promotes, for example, the integration into cropping systems of pulses and legumes that help build up and maintain soil nitrogen levels.

Worldwide, conservation agriculture has been adopted on some 117 million ha, or about 8 percent of total world cropland. The highest adoption levels – above 50 percent of cropland – are found in Australia, Canada and the southern cone of South America. Adoption has been low in Africa, Central Asia and China, but it is increasing (FAO, 2011a). However, high levels of dis-adoption have also been observed, underscoring the need for a nuanced approach that takes into account different factors, such as the effects of climate change, as well as barriers to adoption (Arslan *et al.*, 2013; Grabowski *et al.*, 2016; IAPRI, 2016).

Agroecology represents a shift from 'ready-to-use' to 'custom-made' production systems. Farmers achieve a greater quality and quantity of production by transitioning from a reliance on chemical inputs to a holistic, integrated approach based on ecosystem management. This is done by re-introducing biological complexity, particularly by increasing plant diversity, perennial cover and the presence of trees. By closing the nitrogen cycle, agroecological farming improves the efficiency of food production and provides a number of environmental co-benefits, including reduced waste and pollution at landscape level and increased economic efficiency at farm level (FAO, 2015).

Climate-smart agriculture aims at sustainably increasing food security and incomes, and adapting and building resilience to climate change, while capturing potential mitigation co-benefits. It connects other innovations, such as conservation agriculture, agroecology, agroforestry and the development of crop varieties that are more tolerant to pests, diseases, drought, waterlogging and salinity (FAO, 2013). More than 30 countries in sub-Saharan Africa explicitly referred to climate-smart agriculture in their Intended Nationally Determined Contributions, which aim at reducing GHGs emissions and were prepared for the 21st Conference of the Parties of United Nations Framework Convention on Climate Change, held in Paris in December 2015.

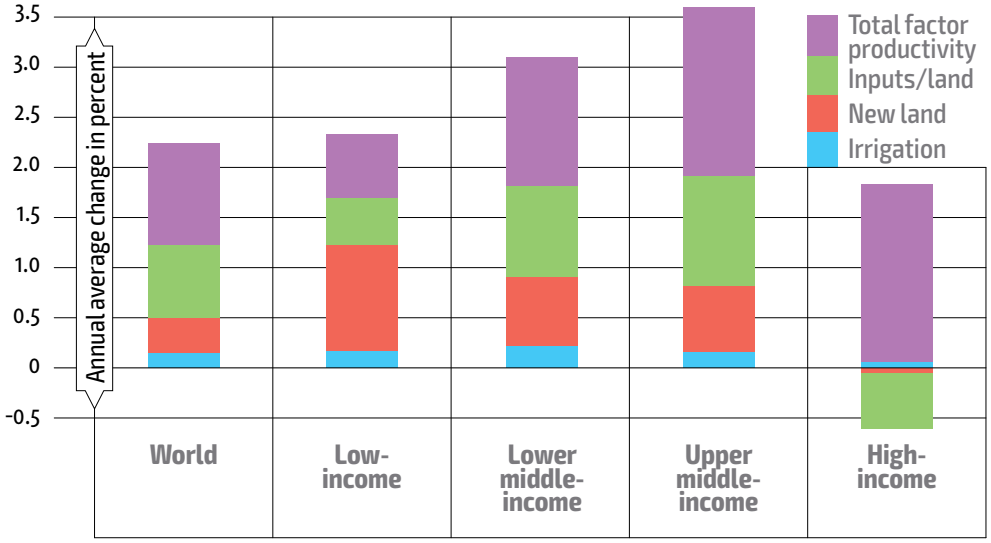
Climate-smart agriculture has promoted mixed crop-livestock systems and sustainable livestock production, which integrate environmental and production objectives through, for example, the rotation of pasture and forage crops to enhance soil quality and reduce erosion, and the use of livestock manure to maintain soil fertility. In climate-smart agriculture, agroforestry systems are an important means of sustainably producing food while conserving ecosystems, especially in marginal areas prone to environmental degradation.

In the fisheries and aquaculture sectors, 'blue growth' approaches focus on improving productivity and performance through climate-resilient systems.[3] Opportunities for blue growth encompass improved marine and freshwater fisheries systems, aquaculture, aquaponics and other forms of

combined aquaculture/agriculture production. Blue growth approaches also offer opportunities for innovation in production environments where agriculture is not possible, such as brackish water and saline systems. This will be particularly useful in countries where climate change adaptation will focus on building resilience and improving disaster risk management in marine waters and coastal areas, and addressing the multiple stresses on inland waters.

The adoption of improved agricultural practices would contribute to increased total factor productivity (TFP) in agriculture. TFP refers to increases in agricultural output owing to an overall increase of efficiency of production processes, rather than through the intensification of input use. Globally, TFP growth accounted for about 40 percent of production increases between 1961 and 2010 (Figure 5.2). It has become increasingly important over time, with growth averaging around 2 percent per year since 2000. In high-income countries, TFP growth has been the main contributor to increases in agricultural output. While output in low-income countries has increased mainly through the expansion of agricultural areas, over the last decade TFP growth has increased significantly (USDA, 2016).

Figure 5.2 Sources of growth in agricultural production, by country income group, 1961–2010



Source: Based on Fuglie, 2012.

[3] In July 2016, the 122 countries represented on the FAO Committee on Fisheries reiterated their support for blue growth.

Some large countries, such as Brazil, China, Indonesia, the Russian Federation and Ukraine have achieved TFP growth rates above their regional average. Overall growth of TFP is lagging in sub-Saharan Africa, although countries such as Benin, Cameroon, Congo, Kenya, Mali and Sierra Leone have registered above-average growth rates in the 2000s (Yu and Nin-Pratt, 2011). However, sub-Saharan Africa's large potential for much higher agricultural production has not been realized. A key strategy for achieving long-term increases in agricultural production in the region is sustainable agricultural mechanization, which can deliver multiple benefits, including reduced drudgery for small-scale farmers, improved timeliness in

farming operations and increased efficiency of input use. In the longer term, mechanization would support the sustainable intensification of production systems and help to build an agriculture sector that is more resilient to increasingly extreme and unpredictable climatic events.

In countries with a large proportion of small family farms, promoting innovation that leads to higher TFP growth is essential for ensuring productive and sustainable agriculture. Similar arguments apply to aquaculture. In the long run, productivity growth in agriculture as a whole requires continuous technological progress, as well as social innovations and new business and investment models.

There is widespread awareness that the adoption and adaptation of sustainable farming systems and practices, such as conservation agriculture, agroforestry, integrated crop-livestock-energy systems and integrated pest management, require technological innovation and investment in research and development (R&D). Investment is also needed to implement and support new organizational forms of R&D that are closer to farmers' needs, as highlighted for instance through the experiences of farmer field schools (FAO and INRA, 2016; European Commission, 2007). Last, but not least, an institutional enabling environment is crucial to ensure the effective implementation of sustainable farming systems and to support their promotion and adoption.

After a period of stagnation, agricultural R&D is surging

Following a decade of slowing growth in the 1990s, global expenditure on agricultural R&D increased by an average of 3.1 percent a year during the period 2000–2009 (Table 5.3), rising from US$25 billion to US$33.6 billion. Spending by China and India accounted for close to half of the increase. Argentina, Brazil, Iran, Nigeria, and the Russian Federation also significantly increased their spending on public agricultural R&D, and collectively accounted for one-fifth of the total increase in spending worldwide. Among low-income countries, annual R&D spending grew by 2.3 percent, driven largely by increases in Ethiopia, Kenya, Uganda and the United Republic of Tanzania.

A commonly used indicator of a country's agricultural research efforts is 'agricultural research intensity' (ARI), which indicates national public expenditure on agricultural R&D as a share of agricultural gross domestic product (GDP). While there is no 'right' level of ARI, overall government R&D expenditure for science and technology of at least 1 percent of national GDP has been recommended (ECOSOC, 2004). For the agriculture sector, countries in both the low-income and the lower middle-income groups are generally far below this target, although there are major differences within the groups (Figure 5.3).

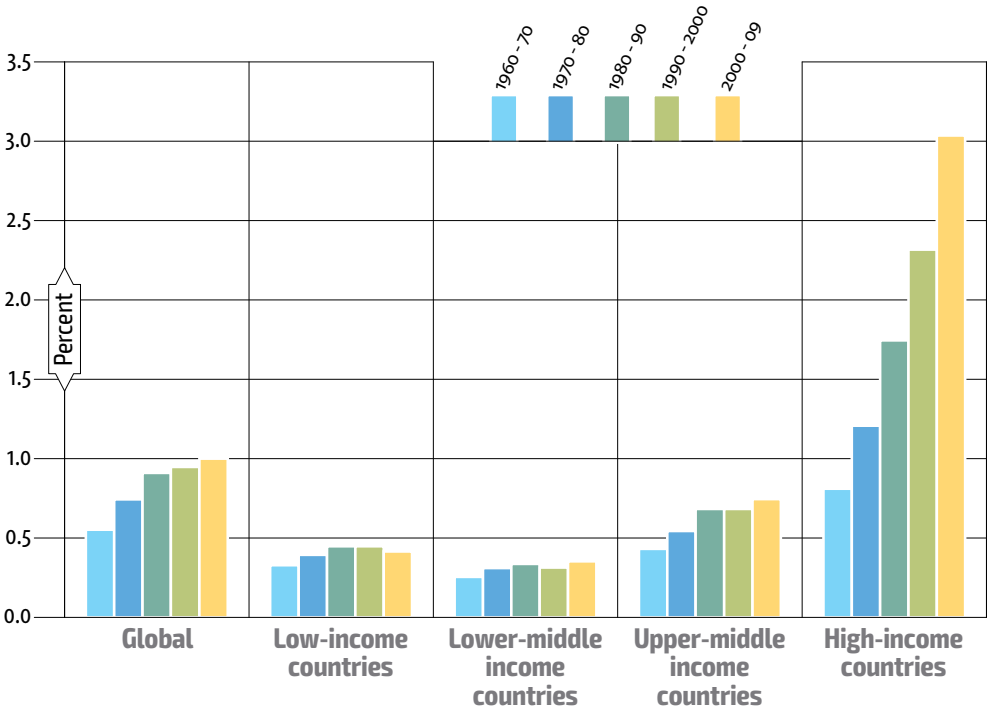
Private investment in R&D increased from US$12.9 billion in 1994 to US$18.2 billion in 2008 (Beintema *et al.*, 2012). Global private investment in R&D in agriculture and food processing accounted for about 21 percent of total R&D expenditures in 2008. Almost all private research takes place in high-income countries. However, it has grown in India (Pray and Nagarajan, 2012) and China (Pal, Rahija and Beintema, 2012), where it accounts, respectively, for 19 percent and 16 percent of total agricultural

Table 5.3 Real growth of public spending on agricultural R&D (percent)

	1960-70	1970-80	1980-90	1990-2000	2000-09
Country group					
Low-income	6.0	4.1	3.1	1.0	2.3
Lower middle-income	6.7	3.3	3.1	3.2	4.6
Lower middle-income (excl. India)	5.4	4.1	2.0	0.8	4.1
Upper middle-income	4.3	6.6	2.8	2.1	6.2
Upper middle-income (excl. China)	6.1	6.2	1.9	1.1	3.0
High-income	9.1	3.3	2.1	1.6	1.0
East Asia/Pacific (incl. China)	2.4	5.6	4.6	3.4	8.7
China	-0.1	7.8	5.1	3.9	9.9
Latin America/Caribbean	4.4	9.7	1.0	0.9	2.5
Middle East/North Africa	9.0	2.0	5.2	2.5	3.0
South Asia (incl. India)	8.2	3.2	5.7	5.3	4.4
India	9.8	1.7	5.6	6.7	5.2
Sub-Saharan Africa	5.7	2.7	0.6	-0.5	4.0
World	7.6	4.1	2.4	1.9	3.1

Source: Pardey, Chan-Kang and Dehmer, 2014.

Figure 5.3 Averages of agricultural research intensity, by country income group



Note: Simple average of annual agricultural research intensity (ARI), measured as the ratio of public expenditure on agricultural R&D to agricultural GDP.

Source: Pardey, Chan-Kang and Dehmer, 2014.

R&D spending (excluding food processing). No such figures are available for aquaculture. Until recently, private agricultural R&D was concentrated in the machinery and chemical sectors. There has been a recent surge in private investment in the life sciences, driven partly by changes to the governance of intellectual property rights for biological innovations (Wright and Pardey, 2006).

Estimates of the rates of return to agricultural R&D suggest it has a very high social value. Estimated annual internal rates of return on investments on agricultural R&D range between 20 percent and 80 percent (Alston, 2010). In low-income countries, the dollar-for-dollar impact of R&D investments on the value of agricultural production is generally within the range of 6 to 12 percent (Fan, Yu and Saurkar, 2008; Fan and Zhang, 2008; FAO, 2012).

Citizen resistance to GMOs risks overshadowing the contribution of other biotechnologies

Agricultural biotechnology, defined as 'any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use' (CBD, 2013) can make a significant contribution to productive and sustainable agriculture. Biotechnologies range from low-tech approaches, such as artificial insemination, fermentation techniques and biofertilizers, to high-tech approaches and advanced DNA-based methods, such as genetically modified organisms (GMOs).

A major, and polarizing, debate about GMOs has been underway since the 1990s.[4] This debate revolves around their potential impacts on food security, the environment, biodiversity, human and animal health, and control of the global food system. It is claimed that genetic modification can help, in some circumstances, to increase production and productivity.[5] However, GMOs raise concerns about potential risks to human and animal health and to the environment. Potential risks and benefits need to be carefully evaluated on a case-by-case basis.

One unfortunate consequence of this long-running debate is that the achievements of other biotechnologies have been overshadowed. For example, New Rice for Africa (NERICA) varieties have been developed using biotechnologies that enable African and Asian species of cultivated rice to be crossed. NERICA varieties, which combine the high yields of Asian rice with the ability of African rice to thrive in harsh environments, are now widely distributed in sub-Saharan Africa.[6] Adoption of such 'biotech crops' is the most pronounced crop technology trend of recent years (James, 2014). Another example is the current development in China of perennial rice, which is capable of re-growing season after season without need for reseeding.

Investment patterns in biotechnology R&D are highly uneven. China's budget for agricultural biotechnology is 10 times that of Brazil and India, but those two countries vastly out-spend the whole of sub-Saharan Africa. Since most new biotechnologies have been developed outside low-income countries, improved North-South links that facilitate capacity building and technology flow are crucial. The lack of adequate and sustained investments remains a major limitation in most low-income countries. Moreover, many

[4] In aquaculture, the only genetically modified farmed fish, the AquAdvantage Atlantic salmon, attains market size in 16 to 18 months, rather than three years. However, critics argue that because aquaculture remains largely based on the rearing of fish that differ little from wild relatives, there is much to be gained from application of conventional selective breeding, without resorting to technologies whose risks are not fully understood and which produces a product with unproven public acceptance.

[5] A comprehensive global meta-analysis of 147 published biotech crop studies over the last 20 years worldwide found that on average GMO technology adoption has reduced chemical pesticide use by 37 percent, increased crop yields by 22 percent, and increased farmer profits by 68 percent (Klümper and Qaim, 2014). In 2014, GMO crops were grown in 28 countries on 181.5 million ha, up from 1.7 million ha in 1996. 18 million farmers grow GMO crops, including 14.8 million farmers in China and India.

[6] The above heavily borrows from the web site of the International Symposium on 'The role of biotechnologies in sustainable food systems and nutrition' (available at www.fao.org/about/meetings/agribiotechs-symposium/faqs/en) (FAO, 2016b).

biotechnology products, such as new crop varieties, have been developed by private sector companies, which have no explicit commitment to public goods. To facilitate the uptake of agricultural biotechnologies and improved non-commercial staple crops in low-income countries, without compromising the processes that lead to innovation, public-private partnerships are making the products of existing biotechnologies available to smallholders in areas where the private sector has little commercial interest.

Nanotechnology also offers opportunities for innovation. Already, nanotechnology-based food and health food products, and food packaging materials, are available in some countries, and it is expected that they will be increasingly available to consumers worldwide in the coming years (FAO and WHO, 2010). However, despite the numerous potential advantages of nanotechnology, agricultural applications have not yet made it to the market. The main factors limiting the development of these applications are low levels of investment in workforce training and research infrastructure (Parisi, Vigani and Rodríguez-Cerezo, 2015).

Citizen resistance to biotechnology and nanotechnology, as well as fears of commercial losses, have also played a significant role in limiting the use and spread of these technologies. These trends are found across the world (David and Thompson, 2008; Gruère and Sengupta, 2009; Aerni and Bernauer, 2006; Fairfield-Sonn, 2016; Stilgoe, Owen and Macnaghten, 2013). Recent policy emphasis on responsible research and innovation may help to improve citizen-science dialogues around the introduction of new and emerging technologies (Stilgoe, Owen and Macnaghten, 2013).

Mobile phones and farmer field schools also contribute to agricultural innovation

Information and communications technologies are playing an increasingly important role in keeping farmers and rural entrepreneurs informed about agricultural innovations, weather conditions, input availability, financial services and market prices, and connecting them with buyers. Mobile phones have great potential for promoting inclusiveness. They allow fishers and aquaculture producers, for example, to market their perishable produce more effectively and command better prices as a result. Mobile phone subscriber penetration stands at almost 60 percent in low-income countries, and is still growing rapidly. By 2020, more than 90 percent of the incremental 1 billion new mobile subscribers are forecast to be in low- and middle-income countries (GSMA, 2016). Mobile phones shorten the distance between previously isolated smallholders and other actors involved in producing, processing, transporting, marketing, and regulating food (Conway, 2016). They can also speed up the supply of inputs through e-vouchers and real-time tracking of inventory.

Face-to-face extension services are being complemented, and sometimes replaced, by mobile phones, the Internet and more conventional media, such as radio, video and television. In many countries, extension services have evolved away from top-down 'technology transfer' to participatory and discovery-based approaches that inspire innovation. Farmer field schools support farmers in building their technical and organizational skills, adapting technologies to local needs and blending them with

local knowledge. The farmer field schools approach has spread to more than 90 countries and has been used to train an estimated 20 million farmers. Action research involving farmers, scientists, rural advisors and non-governmental organizations (NGOs), as well as farmer-researcher networks, have also had significant success.

The reduction in public extension services has been accompanied by growth in private sector dissemination of technologies and practices. Despite the growing importance of private services, for both economic and social reasons, there is still a clear need in many countries for governments to maintain a role in providing advice to farmers (Compagnone, Goulet and Labarthe, eds., 2015). Creating closer linkages between R&D and extension, particularly using farmer-led research and other learning-based approaches, has proved an effective means of expanding the adaptation and adoption of technology (Darnhofer, Gibbon and Dedieu, 2012).

The application and dissemination of technologies is changing. Although they present opportunities for raising productivity and meeting new challenges, they also carry the risk of aggravating disparities between high-income countries and countries with the highest rates of hunger and poverty. Because public and private investment in R&D is concentrated in high-income countries and a few emerging countries, the growing importance of biotechnology means that yield gaps for lower-income countries are likely to widen further.

Ownership of new technologies by the private sector often restricts their diffusion in countries that are already least able to afford them, but where the benefits could be substantial. This underscores the importance of regulation and the strengthening of providers of public goods, such as the CGIAR and regional and national agricultural research systems. Public intervention is required for R&D in support of resource-conserving approaches, such as conservation agriculture and climate-smart agriculture, which may attract limited private investment.

6 | Transboundary pests and diseases

Food security is threatened by an alarming increase in the number of outbreaks of transboundary pests and diseases of plants and animals. These pests and diseases jeopardize food security and have broad economic, social and environmental impacts. A worrying trend is the upsurge in zoonotic diseases, such as avian influenza and swine flu, which can also have serious repercussions on human health. Climate change is, in part, responsible for food chain emergencies arising from transboundary threats. However, while there is clear evidence that climate change is altering the distribution of animal and plant pests and diseases, the full effects are difficult to predict.

With globalization, the risks to crops and livestock are increasing

Transboundary animal diseases are highly contagious epidemic diseases that spread rapidly across national borders, causing high rates of death and illness. The risk of serious outbreaks is increasing as more people, animals, plants and agricultural products move across international borders, and as animal production systems become more intensive. Because they can have serious socio-economic consequences, including the disruption of regional and international livestock markets and trade, transboundary animal diseases are a constant threat to the livelihoods of livestock keepers, especially in low- and middle-income countries. They undermine food security and prevent livestock sectors from achieving their full economic potential. In recent years, the world has suffered several pandemics of emerging or re-emerging transboundary animal diseases, such as bovine spongiform encephalopathy and highly pathogenic avian influenza.

The spread of transboundary animal diseases is facilitated by the lack of access to goods and services in rural areas, and the disruption of veterinary services and trade in livestock and animal products. A good example is lumpy skin disease, which affects livestock throughout Africa and is spreading quickly to the Middle East, Asia and Europe (Alkhamis and Van derWaal, 2016). Recent upsurges (Figure 6.1) have been facilitated by poorly regulated movements of large numbers of animals and seasonal fluctuations in populations of biting insects that spread the virus (FAO, 2015).

Foot-and-mouth disease (FMD) is another highly contagious disease that affects many countries in Africa, Asia and the Middle East. In the United Kingdom, the economic impact of FMD was estimated at US$14 billion (NBCA, 2016). More than 100 countries are not considered FMD-free and represent a permanent threat to disease-free countries. Other transboundary diseases, such as African swine fever (FAO, 2013a; Arias *et al.*, 2015),

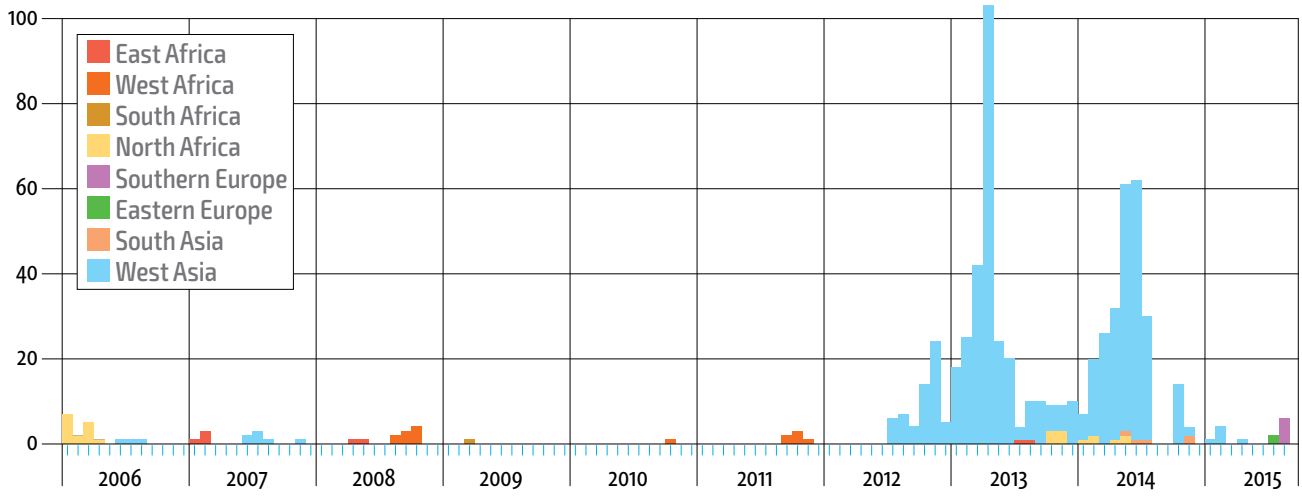
Newcastle disease (Ashraf and Shah, 2014) in poultry and contagious bovine pleuropneumonia in cattle in Africa, have severe negative impacts on the animal industry, mainly in low-income countries, as well as on regional and international livestock markets.

Following the highly successful campaign against rinderpest – FAO and the World Organisation for Animal Health (OIE) officially declared the disease eradicated in June 2011 – both organizations launched in 2015 a global strategy for the control and eradication of the *peste des petits ruminants* (FAO and OIE, 2015, p.88). This disease severely affects small ruminants in almost 70 countries of Africa and the Middle East, as well as parts of Asia. Highly contagious, it causes US$1.5 to US$2 billion in losses each year in regions that are home to more than 80 percent of the world's sheep and goats and more than 330 million of the world's poorest people, many of whom depend on small ruminants for their livelihoods.

Healthy livestock is crucial for achieving the sustainable production of nutritious and accessible food for everyone. However, given the magnitude of the disease problem, and its entomological, veterinary, medical, public health and environmental dimensions, no single specialized organization can address the risks of a given disease, and prevent, control and eliminate it. Committed international coordination is needed to develop and implement collective global health protection strategies under the umbrella of the One Health concept (FAO, 2011).

Major transboundary plant pests and diseases include insect pests, such as locusts, which are major threats to the agro-pastoral resources and livelihoods in Africa and Asia, armyworms and fruit flies; and crop-specific diseases, such as rust diseases in wheat, coffee and soybean, wilt diseases of banana and viral diseases of cassava and maize. These pests and diseases move rapidly to threaten neighbouring countries, regions and continents.

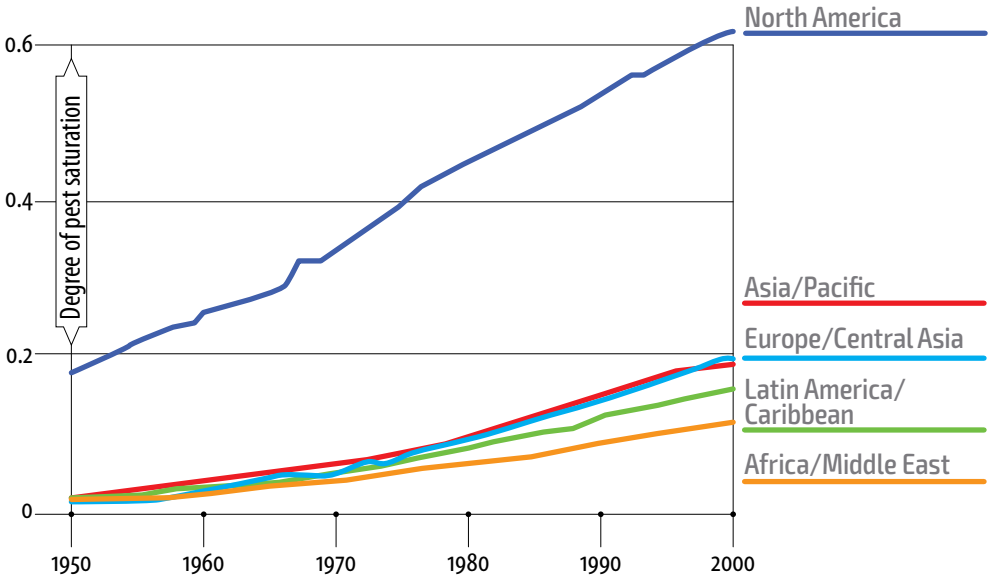
Figure 6.1 Reported outbreaks of lumpy skin disease, per month, 2006–2015



Source: FAO, 2015.

The impacts of transboundary plant pests and diseases vary from region to region and year to year. In some cases, they result in total crop failure. Globally, annual crop losses to plant pests are estimated to be between 20 to 40 percent of production. In terms of economic value, plant diseases alone cost the global economy around US$220 billion annually (Agrios, 2005) and invasive insects around US$70 billion (Bradshaw *et al.*, 2016).

Figure 6.2 Global spread of crop pests and pathogens, 1950–2000



Note: The degree of pest saturation for a region is the mean of the degrees of saturation of countries in that region. The degree of saturation in a country is the number of crop pests and pathogens (CPPs) currently present divided by the number of CPPs that could occur.
Source: Bebber, Holmes and Gurr, 2014.

A study analysing trends in the occurrence of plant pests and diseases (Figure 6.2) found that the degree of saturation for each pest has reached almost 10 percent in Africa, 20 percent in Asia, and even 60 percent in North America (Bebber, Holmes and Gurr, 2014). On average, 10 percent of the major plant pest and disease agents have already infested half of the countries that they could, theoretically, have infested. Trends in the spread of these pests and disease agents into new environments are increasing.

The movement of planting materials, trade and travellers can be vehicles for the long-distance transmission of plant pests and diseases. Certain diseases, such as wheat and coffee rusts, and pests, such as locusts, are airborne and can easily be spread by the wind across borders. Insect vectors also play an important role in the local spread of many viral and bacterial disease agents, such as the banana bunchy top disease, cassava mosaic diseases and maize lethal necrosis disease, which are major threats to key staple crops for millions in Africa, Asia, and Latin America.

Regular surveillance, integrated approaches, international collaboration and adequate preparedness are essential for preventing transboundary plant pests and diseases and preparing a timely response to protect crops. Because it reduces losses of both crops and pastures, the control of these pests and diseases enhances overall agricultural productivity.

This is also true with regard to the transboundary spread of forest pests and diseases, which can negatively impact forest health and the production of forest ecosystem services, which in turn affects food production and the availability of fuelwood for cooking and food processing.

The prevention of transboundary plant pests and diseases has proved to be the most effective control strategy. While reducing losses to crops and rangelands, it minimizes pesticide use and negative environmental impacts and requires less investment. In some cases, prevention might be the only way to protect crops, as other control options may be highly limited. This approach has been followed by FAO's highly successful programme for desert locust prevention and control, which has reduced the duration, intensity and frequency of plagues that historically lasted for up to 15 years and affected 50 countries. The recurrent cost of implementing the desert locust prevention in West and Northwest Africa has been estimated at US$3.3 million a year, while the cost of bringing the 2003–2005 plague under control was nearly US$600 million, equal to 170 years of prevention (FAO, 2014).

Zoonotic diseases and antimicrobial resistance pose a growing threat to human health

Many transboundary zoonotic diseases that are naturally transmitted among animals can also infect humans. In fact, more than 70 percent of the infectious diseases that have emerged in humans since the 1940s can be traced back to animals, including wildlife (Jones *et al.*, 2008). Among the best known are severe acute respiratory syndrome and associated corona viruses in bats and other mammals; henipaviruses in swine, bats and horses; Ebola virus in wildlife; and the rabies virus and associated viruses (Bennet, 2006; Calisher *et al.*, 2006; FAO, 2013b, p.111; Jones, 2008; Turmelle and Olival, 2009).

The rapid spread of the H5N1 avian influenza virus in Southeast Asia in 2004 and, from there, to Europe and Africa in 2005, aroused fears that a human influenza pandemic might emerge from domestic poultry. More than 60 countries were affected by virus incursions. Poultry losses amounted to more than 300 million birds, and producers suffered economic losses running to US$3.3 billion in the United States and US$2.9 billion in Egypt (Green, 2015; KUNA, 2006). Another virus, H1N1, was responsible for a worldwide epidemic of swine flu that affected humans in 2009. Rift Valley fever, which affects animals primarily but also has the capacity to infect humans, continues to threaten parts of Africa, and could spread to the Middle East and southern Europe. Ebola outbreaks in West Africa in 2014 had serious consequences for affected countries and caused global alarm.

Middle East respiratory syndrome (MERS), also known as 'camel flu', is another example of the worrisome trends in the global spread of pathogens. Since it first emerged in the Middle East in 2012, MERS has spread to more than 20 countries on four continents, affecting mainly camel handlers and healthcare workers. Between 30 and 40 percent of infected humans die (Zaki *et al.*, 2012; de Groot *et al.*, 2013).

Age-old endemic zoonotic diseases, such as brucellosis, tuberculosis, anthrax and rabies, and vector-borne diseases, such as trypanosomiasis, do not get media headlines. However, they remain serious threats to

human and animal health, and to household food security and nutrition, particularly in poor and vulnerable communities. In sub-Saharan Africa, annual losses due to trypanosomiasis are estimated at between US$6 billion and US$12 billion in the cattle industry alone (Hursey and Slingenbergh, 1995) and up to 10 percent of agricultural GDP in 10 fully tsetse-infested countries (Mattioli *et al.*, 2004). Ticks and tick-borne diseases cause global losses estimated in the range of US$18 billion (de Castro, 1997).

The potential impact of animal diseases on human health is magnified further by increasing levels of resistance in bacteria, parasites, viruses and fungi to antimicrobial drugs, such as antibiotics, antifungals, antivirals, antimalarials and anthelmintics. Antimicrobial resistance (AMR) is spreading globally, undermining the ability to treat common infectious diseases and resulting in prolonged illness, disability and death. Today, some 700 000 people die of drug-resistant infections every year. Low- and middle-income countries face the greatest burden of rising drug-resistant infections, and their consumption of antibiotics is predicted to increase.

Antimicrobials are heavily used not only to preserve human and animal health but, more broadly, in livestock production. A review of AMR has estimated that, if no action is taken today, by 2050 drug-resistant infections will place at risk some 10 million human lives a year and a cumulative US$100 trillion in economic output (O'Neill, 2016).

Enhancing international and regional cooperation and coordination is crucial to preventing transboundary zoonotic disease at source. The One Health multidisciplinary approach (FAO, 2011) is considered the best strategy to promote and integrate immediate and long-term disease intervention strategies. To address the issue of AMR, the World Health Organization has developed a Global Action Plan with clear responsibility in the food and agriculture sector. It addresses food safety, terrestrial and aquatic animal production and health, crop production, water and soil management, and agriculture and commercial regulatory frameworks. FAO is working closely with WHO and the OIE in advising countries, the medical community and agricultural producers on the appropriate use of antimicrobials and providing guidance to minimize the threat of AMR.

Climate change and natural resources degradation are modifying pest and disease dynamics

Climate change and change in land cover, such as deforestation and desertification, can make plants and animals more vulnerable to pests and diseases. Changes in temperature, moisture levels and concentrations of atmospheric gases can stimulate the growth and generation rates of plants, fungi and insects, altering the interactions between pests, their natural enemies and their hosts.

Some of the most dramatic effects of climate change on transboundary animal diseases are likely to be seen among insect vectors, such as mosquitoes, midges, ticks, fleas and sand flies, and the viruses they carry. With changes in temperatures and humidity levels, the populations of these insects may expand beyond their present geographic range, and expose animals and humans to diseases to which they have no natural immunity.

For example, climatic changes could influence the risk of the emergence, transmission and spread of Rift Valley fever, a zoonotic, viral and vector-borne disease that poses a threat to human and animal health.

Climate change, changes in environmental conditions and increasing pressure on land can modify not only animal production and productivity but also disease dynamics at the human-animal-ecosystem interface. They can affect the worldwide redistribution of vectors, pathogens and infected hosts, setting off novel epidemiological patterns and driving the spread of many endemic diseases, such as bluetongue and West Nile viruses, into new areas (Kilpatrick and Randolph, 2012; de la Rocque *et al.*, 2011).

In part, climate change is also responsible for the upsurge in transboundary plant pests and diseases. It is modifying the dynamics of pest populations, such as locusts, and creating new ecological niches for the emergence or re-emergence and spread of pests and diseases. The effects of climate change could be felt in a number of ways, such an increase in the frequency of outbreaks, the expansion of pests into new environments, the evolution of new pest strains and types, and increases in the vulnerability of plant defence mechanisms.

Global warming is expected to lead to a general intensification of certain important plant pests and diseases and their spread into larger areas. A recent analysis indicated an average annual 2.7 km poleward movement of crop pests owing to global warming (Bebber, Ramotowski and Gurr, 2013). Recent examples of such outbreaks and expansions are coffee leaf rust epidemics in Central America (Avelino *et al.*, 2014) and recurring wheat rust epidemics (Hodson, 2011). Similar effects of warming can lead to the intensification and expansion of cassava virus diseases and the banana top disease virus in some environments of the tropics, which are also linked to the increased the mobility of insect vectors (Anhalt and Almeida, 2008).

Complex interactions among the biological elements could also add to the challenge of addressing the impacts of climate change. While drier conditions might suppress some pests and diseases they can, at the same time, make crops more vulnerable to others. The increased incidence and intensity of tropical storms and floods can spread certain soil- and water-borne plant diseases. Changes in temperature and rainfall can contribute to the faster evolution of new and more aggressive strains and types of plant pests and diseases, which may affect crop varieties that are now resistant or tolerant. One example of this phenomenon is the evolution of strains of wheat yellow rust that have adapted to higher temperatures and damaged wheat crops in the Near East, Central Asia, Australia and the Americas in the 2000s (Milus, Kristensen and Hovmøller, 2009).

In developing strategies for improved adaptation and resilience to climate change, it is important that both the perspectives of the crop and the pest are considered. For example, cassava is considered a promising crop that could play an important role in making crop production systems more resilient to climate change in tropical environments. However, when taking advantage of this potential, national programmes need to be aware that, with higher temperatures, cassava's viral diseases may also expand with the greater mobility of its vectors.

7 | Conflicts, crises and natural disasters

Conflicts are a major driver of food insecurity and malnutrition. They reduce food availability, disrupt access to food and health care, and undermine social protection systems. Every famine in the modern era has been characterized by conflict (Simmons, 2013). These conflicts are complex by nature. They can be triggered or amplified by climate-related natural disasters and the impact that these have on poverty eradication and food security. Natural disasters tend to trap vulnerable people, in particular, in a cycle of poverty because they are less resilient and lack coping capacity.

Conflicts are on the rise again

The end of the Cold War led to a dramatic decline – more than 60 percent below peak levels – in interstate and societal conflict during the 1990s and into the 21st century. While a growing global population might be expected to provoke an increasing number of violent conflicts, this was effectively inverted between 1995 and 2003. However, the prevalence of conflicts has increased markedly since the early-to mid-2000s, due to the rapid emergence of several factors at both international and national levels (Cilliers, 2015). This is particularly true for civil conflicts, which in recent years have become the most common form of armed conflict. In 2014, there were 424 political conflicts and 46 extremely violent conflicts globally (OCHA, 2016b).

The 2016 Global Peace Index Report (IEP, 2016) concludes that the world became less peaceful in 2015, confirming the underlying trend of declining peace over the last decade. The report also describes a growing 'global inequality in peace', with the most peaceful countries continuing to be so, while the least peaceful fall into greater violence and conflict. The Syrian civil war is now in its sixth year. Conflict persists in parts of the Central African Republic, Iraq, Libya, Nigeria, Somalia, South Sudan, Ukraine, Yemen and elsewhere.

Around 80 percent of humanitarian funding appeals are now related to conflicts, most of them protracted, and about half of the world's poor live in states characterized by fragility and conflict (DI, 2015), up from one-fifth in 1990. Similarly, 93 percent of people in extreme poverty are living in countries deemed as fragile or environmentally vulnerable, or both. Conflicts are becoming more complex and intractable, reflecting their dynamic interrelationships with poverty, hunger and governance (OECD, 2015, p.33).

The main drivers of conflicts include ethnic and religious differences, discrimination and marginalization, poor governance, limited state capacity, population pressure, rapid urbanization, poverty and youth unemployment. Drivers of conflict specific to the agriculture and rural sectors include competition for land, water and other natural resources, food insecurity, environmental mismanagement, and government neglect of poor and marginalized areas, such as arid and semi-arid zones essential for livestock-dependent populations and subsistence fishing grounds.

Countries with the highest levels of hunger are usually those with conflicts

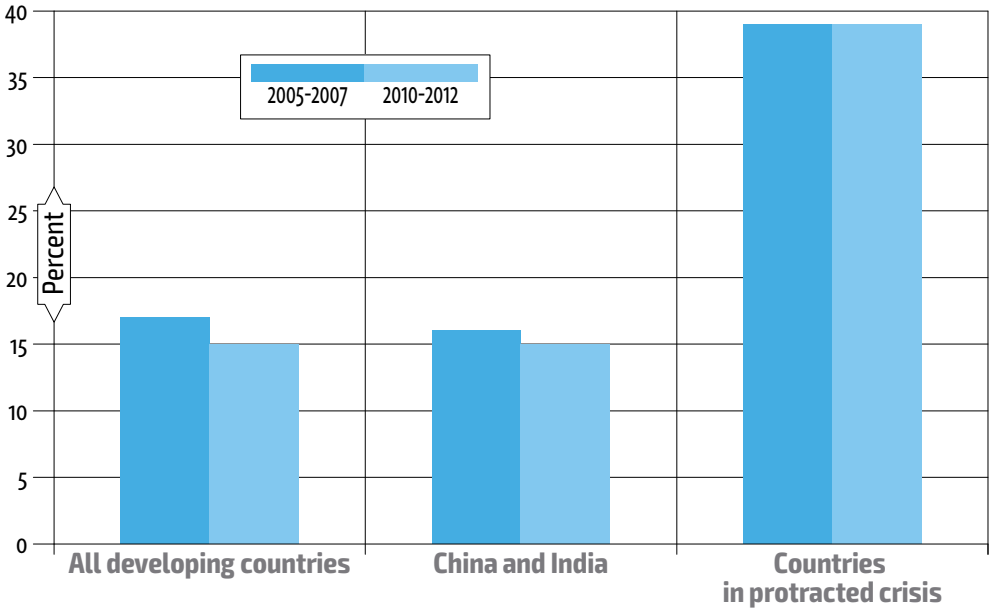
Conflicts in rural areas, especially civil conflicts,[1] can heavily affect agricultural production and livelihoods (Center for Systemic Peace, 2012). Vulnerable people and at-risk communities lose access to the range of resources necessary for food and agriculture production, through the seizure of natural resources and displacement from land, homes, fishing grounds and grazing areas. Denials of access, as well as the destruction of food stocks, which are increasingly used as tactics of war, are in direct violation of international humanitarian and human rights laws.

Countries with the highest levels of undernourishment tend to be those engaged in, or recently emerged from, violent conflict. High risk of conflicts is a key characteristic of 'fragile states', and the prevalence of hunger rises exponentially with the degree of fragility, and vice-versa.[2] Thus, the Central African Republic and Chad, among the worst-scoring countries, have both experienced violent conflict and political instability in recent years; in Angola, Ethiopia and Rwanda, hunger levels have fallen substantially since the end of the large-scale civil wars of the 1990s and 2000s.

[1] Civil conflicts are those between a state and an opposition group that aims to take power over the central government, or in a region, or to change government policies.

[2] The fragility of states has five dimensions: violence, justice, institutions, economic foundations and resilience (OECD, 2015). Each year, the fragility of 178 nations is ranked in the Fragile States Index, which is based on 12 key political, social and economic indicators (see FFP, 2016).

Figure 7.1 Prevalence of undernourishment and protracted crises



Source: FAO, IFAD and WFP, 2015, p.37.

Violent conflict also frequently characterizes protracted crises, in which a significant proportion of the population is acutely vulnerable to death, disease and disruption of livelihoods over a prolonged period of time.[3] On average, the proportion of undernourished people living in low-income countries with a protracted crisis is between 2.5 and 3 times higher than in other low-income countries (Figure 7.1). In 2013, around 172 million people in countries with protracted crisis were undernourished – roughly 20 percent of the world's undernourished people.

Of the 21 countries with protracted crisis in 2013, only Ethiopia reached the Millennium Development Goal (MDG) target of halving the proportion of undernourished in the population, largely due to sustained political commitment and interventions to improve food production and nutrition (FAO, IFAD and WFP, 2015). All other countries reported either insufficient progress or deterioration.

Recent conflicts, such as the ongoing civil war in the Syrian Arab Republic, a middle-income country, have led to massive displacement of people and widespread hunger and malnutrition. Of the estimated 13.5 million Syrians in need of humanitarian assistance, some 9.4 million, or more than half of the people remaining in the country, are food insecure. Compared to the pre-conflict averages, livestock numbers have been reduced by half and wheat production is down by 40 percent (FAO, 2016a), and is expected to deteriorate further. Similarly, in South Sudan, the livestock sector, a key livelihood source, lost an estimated US$2 billion in potential GDP during conflict in 2013–15 (FAO, 2016b).

Food insecurity and famine often cause more deaths than direct violence. Between 2007 and 2012 approximately 70 000 people a year lost their lives as a direct result of conflict or terrorism (GDAVD, 2015). In contrast, as a result of famine caused by prolonged drought and conflict, more than 250 000 people died in Somalia alone between October 2010 and April 2012 (FAO, 2013).

Most conflicts strike hardest in rural areas,[4] with major adverse consequences for survival, agricultural production and rural livelihoods. Conflicts disrupt food production through the physical destruction and plundering of crops, livestock and food reserves. They discourage farming, disrupt food transportation systems, destroy farm assets and capital, force or entice young people to fight, and depress income-earning livelihoods and occupations. They also cause psycho-social traumas and disabilities among survivors. There has been a reported rise in conflict-related sexual violence, with rape used as a weapon of war. As a result, survivors suffer from sexually transmitted diseases, stigmatization and trauma, which affects their health as well as productive capacities (UN Security Council, 2015).

In the medium- and longer-term, conflict directly and indirectly undermines agricultural development. Between 1970 and 1997, agricultural losses for all low-income countries owing to conflict averaged US$4.3 billion annually, far exceeding the value of development assistance to those countries (FAO, 2002). Similarly, the presence or risk of conflict discourages private investment in agriculture, even long after conflicts have ended.

[3] See also: CFS, 2015.

[4] A recent analysis of patterns of intensity of conflict and location indicates that whereas violence may be more likely in urban areas, the available data show that rural conflict is more violent. Almost two-thirds of all deaths in state-based armed conflict occurred in rural areas, and the same pattern applies to non-state armed conflict, in which about 60 percent of deaths took place in rural areas. See Björkdahl and Buckley-Zistel, eds. 2016.

The consequences of conflict, including the extreme measures necessary for survival, differ according to the age and gender of those affected. Power relations and social marginalization tend to be amplified as a result of the stressors, and the opportunities for exploitation, that arise during conflicts. The gender inequalities women and girls face limit their access to productive resources, services, and decision-making processes. Thus their relative lack of equality, the burdens they carry as caregivers, their central role in food production, and other responsibilities expose them to particularly vulnerable situations.

Recruitment into fighting forces drains key sources of labour, especially men and boys, for agriculture production. This problem is exacerbated over the long term by war-related disabilities, with the consequent increase in the workloads of women and the elderly in carrying forward the agriculture sector. Rural women take up new economic roles during conflict situations, while their domestic burdens increase (UN Women, 2012; CARE, 2016; Thulstrup and Henry, 2014). The enduring impact of conflicts is also manifested through an increase in the prevalence of malnutrition, especially undernutrition during early childhood, with many of those affected suffering from lifelong physical and mental handicaps.

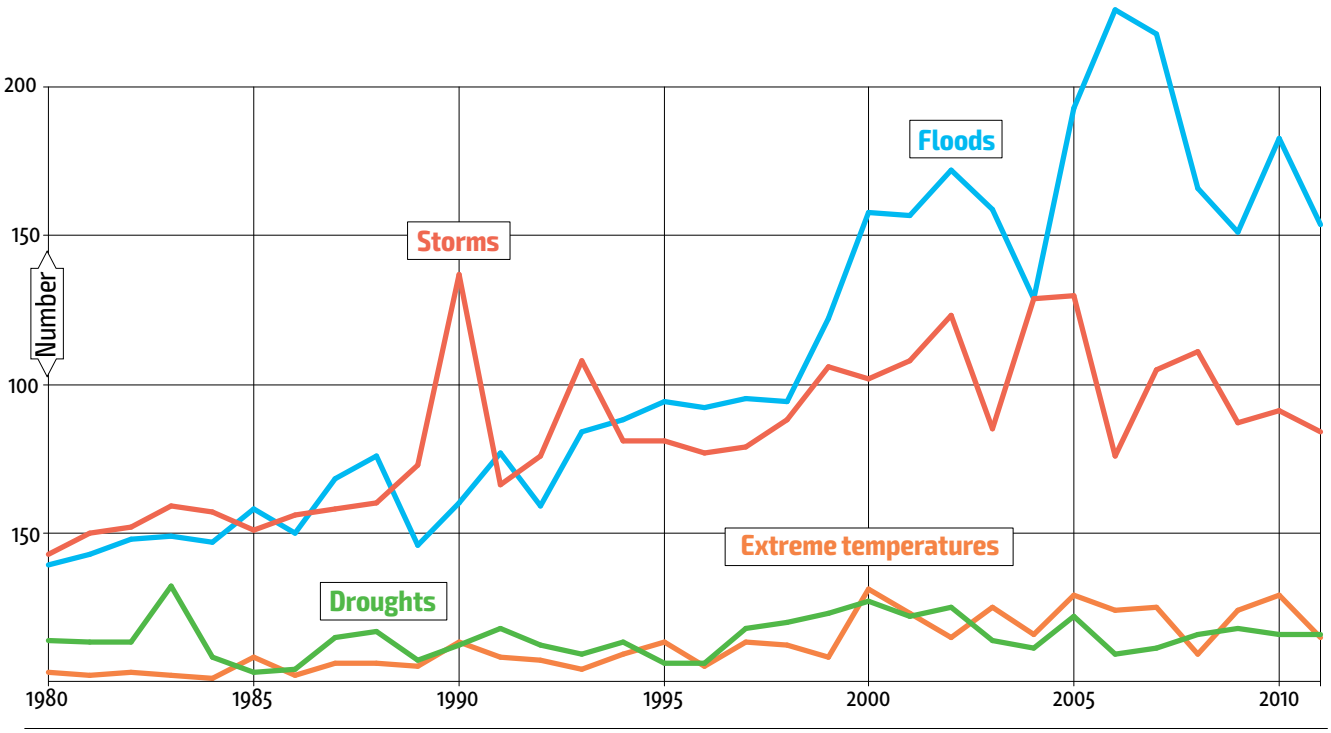
A worrying trend is that the impacts of conflict-induced food insecurity are no longer limited to specific countries or regions, but have become global. In 2015, more than 65 million people worldwide were forcibly displaced, the highest number since the end of the Second World War. Forced displacement is a crisis affecting mainly low-income countries, which host 89 percent of refugees and 99 percent of internally displaced persons. At its root are the same 10 conflicts that every year since 1991 have accounted for the majority of forcibly displaced people, who are consistently hosted by about 15 countries and who are overwhelmingly in the developing world (World Bank, 2016).

The effects of today's conflicts are increasingly echoed across the broader global landscape as conflict-affected people migrate across countries, regions and continents in search of security. There is a deepening awareness of how food insecurity in one part of the world can influence social services, political systems and national security elsewhere.

Agriculture is affected by a rising trend in the number and intensity of natural disasters worldwide

The vulnerability and exposure of individuals and their communities to the impacts of natural disasters depends on a range of factors, including gender, age, socio-economic status and ethnicity (IPCC, 2012). The impacts are often different for men and women, primarily because of gender-determined socio-economic status. A 2007 study conducted by London School of Economics, using a sample of 141 countries over the period 1981–2002, found that, on average, natural disasters and their subsequent impacts cause the deaths of more women than men, and kill women at an earlier age than men (Neumayer and Plümper, 2007).

Figure 7.2 Climate-related disasters, 1980–2011



Source: UNISDR, 2016.

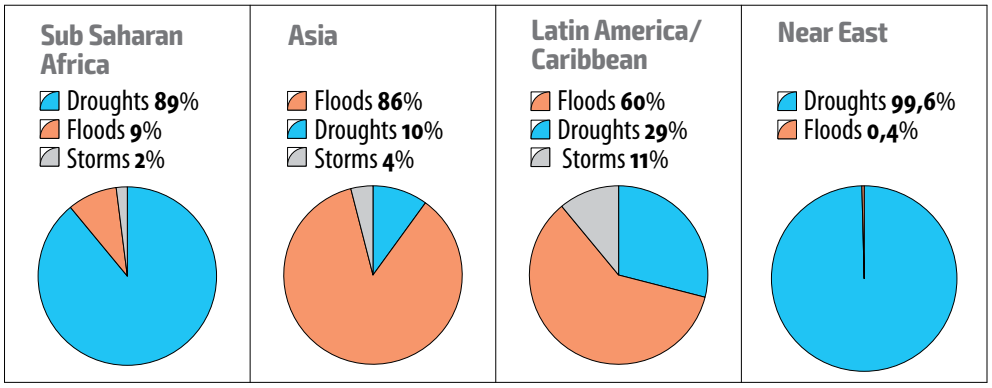
The past 30 years has seen a rising trend in the occurrence of natural disasters (Figure 7.2). This increase is particularly noteworthy in climatological events such as droughts, hydrological events such as floods, and meteorological events such as storms. The increase in weather-related events is of significant concern to agriculture, given the sector's dependence on climate. The intensity of these disasters is increasing, and it may continue to increase as climate changes. For some regions, climate change will result in more intense precipitation, leading to more floods, longer dry periods between rain events, leading to more drought. Droughts are expected to intensify, especially in the subtropics and low- and mid-range latitudes.

The 2015/16 El Niño phenomenon was one of the strongest observed over the last 50 years, and its impacts were felt worldwide. Several severe tropical cyclones affected the Pacific Islands and Southeast Asian countries throughout the 2015/16 cyclone season. The year 2015 was the hottest on record, with the average global temperature much higher than in 2014, which itself was a record. New records are being set in 2016, with July being the hottest ever recorded (Earth Observatory, 2016).

An FAO report on the impact of disasters on agriculture and food security showed that, between 2003 and 2013, the agriculture sector in low-income countries absorbed 22 percent of the impact of natural disasters, including total economic damage to physical assets and infrastructure as well as losses due to changes in economic flows. Agriculture's share rose to 25 percent when only climate-related disasters are considered, and up to 84 percent in the case of drought. Production losses suffered by producers in the aftermath of a disaster were twice as high as the direct damage to agricultural assets and infrastructure (FAO, 2015).

Agriculture subsectors can be affected differently by natural hazards and disasters. Crops tend to be most affected by floods and storms; livestock is overwhelmingly affected by drought; the fisheries subsector is most affected by tsunamis and storms such as hurricanes and cyclones, while most of the economic impact on forestry is caused by floods, storms and wild fires.

Figure 7.3 Agricultural production losses after medium- to large-scale disasters in developing countries, by cause and region, 2003–2013



Source: FAO, 2015.

At the regional level, the types of natural disasters and their impacts on crop and livestock production, reflect differences in climate risks and vulnerabilities. Between 2003 and 2013, drought wreaked the greatest harm on agriculture in sub-Saharan Africa and the Near East; agriculture in Asia was mainly affected by floods; in Latin America and Caribbean, countries were affected mostly by floods, and to a lesser extent by droughts and storms (Figure 7.3).

Food insecurity and the scale of natural hazards reinforce one another. Disasters can have devastating impacts on food security, and food insecurity increases the impact of disasters. This creates a downward spiral in which affected people lurch from one crisis or disaster to the next. To address immediate needs, food insecure people may find themselves forced to take desperate measures, which often compromise their livelihoods, health and dignity, and increase further their vulnerability and exposure to disasters. At the same time, the most vulnerable low-income countries are the ones particularly exposed to the risk of food insecurity and malnutrition resulting from natural disasters.

Natural disasters disrupt agricultural production, ecosystems and livelihoods, affecting the income of farmers and farm labourers. They lower the availability of food commodities in local markets, which leads to food price inflation. These pressures reduce households' purchasing capacity, restrict access to food, deplete savings, force the sale of vital productive assets and erode livelihoods. Ultimately, the quantity and quality of food consumption are reduced, and food insecurity and malnutrition increase, particularly among the most vulnerable households. For instance, the 2010 floods in Pakistan affected 4.5 million workers, two-thirds of whom were employed

in agriculture; more than 70 percent of farmers lost more than half of their expected income (ADB, Government of Pakistan and World Bank, 2010).

There is greater awareness today of the need to reduce and manage disaster risks, particularly in countries facing recurrent disasters and where agriculture is a critical source of livelihoods, food security and nutrition, and a key driver of economic growth. Failure to embed disaster risk reduction (DRR) and disaster risk management (DRM) in development plans and related investments leads to ineffective interventions. As climate change intensifies risks from extreme weather events, DRR needs to be made an urgent priority in these countries if the world is to achieve the Sustainable Development Goals.

The lack of disaster risk planning is a missed opportunity. It has been estimated that emergency aid after a disaster exceeds investments in disaster prevention by almost 7 700 percent (ODI, 2016). DRR is also an entry point for climate change adaptation and resilience building. Opportunities for climate financing need to be created at the national level to establish strong linkages between DRR, climate change adaptation and resilience programming.

Challenges arise when dealing with natural hazards and the impacts of disasters owing to gaps in the availability of, and access to, data and information, including those that are gender-disaggregated. There is no single, harmonized methodology available for collecting data on the causes and impacts of natural disasters specifically in the agriculture sector. Data collection, monitoring and reporting on impacts at the subnational and national level need to be improved and harmonized across countries, to better inform sustainable development planning.

[5] For example, von Uexküll *et al.*, 2016.

Trends indicate that natural hazards, disasters and conflict are more likely to coincide in the future

A number of high-profile disasters in fragile and conflict-affected states have focused attention on the concurrence of natural disasters and conflict, and their combined impact on food security and nutrition. There is an expectation that disasters and conflict will coincide more in the future. Climate change, continued urbanization, food price fluctuations, financial shocks and other stresses may all shape – and complicate – future trends at the disaster/conflict interface and negatively impact food security, nutrition outcomes and overall development.

Extreme weather events related to climate change, which contribute to conflict risks and associated pressure on populations to migrate, are expected to exacerbate a deepening global need for humanitarian assistance. Climate change *per se* is not necessarily associated with violence. However, the intersection between vulnerability to climate change and broader institutional and socio-economic fragility can increase the potential for conflict. New research is identifying relationships between adverse climatic events in agriculturally dependent and politically excluded groups in very poor countries, and increases in the likelihood of sustained violence.[5] This new trend, termed the 'climate-conflict nexus', is the intersection between weak institutions, pre-existing social fragility and climate change vulnerability (OCHA, 2016a).

Similarly, more than 75 percent of the world's poor directly depend on natural resources for their livelihoods. Many may be forced to migrate as a result of the adverse impacts of climate change, with the most widely quoted estimate being 200 million environmental migrants by 2050 (Stern, ed., 2006). A growing number of interrelated, longer-term trends – such as urbanization, rural transformation, resource availability, agricultural productivity, price fluctuations, financial shocks and food insecurity – may impact, or be impacted by, the prevalence of conflict. Where urban and rural institutions are not equipped to manage fluctuating populations along with the allocation of resources and the provision of services, the potential for conflict can increase.

Addressing these emerging challenges calls for prevention through equity, stability and peace building. The Millennium Development Goals neither explicitly nor adequately addressed the rising trend in conflict worldwide. The 2030 Agenda for Sustainable Development does so, by calling for more collaborative approaches to conflict prevention, mitigation, resolution and recovery. It recognizes that peace is a vital threshold condition for development, as well as a development outcome in its own right.

Fostering human rights and greater equity within and between countries is the key to preventing conflicts. Equity in economic development and good governance help address the root causes of violence. The UN system is moving toward an integrated and coherent approach to preventing armed conflicts and crises, predicated on reducing risk, building resilience and sustaining peace. Sustaining peace is expected to be clearly embedded in the 2016 quadrennial comprehensive policy review of the United Nations system. It is important to recognize, however, that conflict-sensitive approaches are needed not only for humanitarian assistance and building resilience, but especially for development support.

8 | Poverty, inequality and food insecurity

Changes in population and income, along with new technological processes, both economy-wide and in food systems, are likely to affect poverty, inequality and food security in all its dimensions. Poverty remains highly concentrated in rural areas. Given persistent inequality, current trends indicate that the goal of eradicating hunger by 2030 will not be achieved.

Globally extreme poverty is decreasing, but in sub-Saharan Africa there are now more extremely poor people than in the 1990s

Extreme poverty, measured in terms of the number of people living below the recently updated poverty line of US$1.90 a day (valued in 'purchasing power parity', or PPP), has significantly declined since 1990, when almost 2 billion people, or more than 37 percent of the world's population, were extremely poor. In 2012, the global prevalence of extreme poverty was put at 12.7 percent, and was projected to fall to 9.6 percent by 2015. The decline in extreme poverty has been especially pronounced in East Asia and the Pacific, and South Asia (World Bank, 2015). However, poverty still affects more than 700 million people worldwide (Figure 8.1). Extreme poverty is persistent in sub-Saharan Africa, where in 2015 close to 350 million people were considered extremely poor, 60 million more than in 1990.

The majority of the extremely poor are still found in Asia. Almost three-fifths of the world's extremely poor are concentrated in Bangladesh, China, the Democratic Republic of Congo, India and Nigeria. These countries along with five others, Ethiopia, Indonesia, Madagascar, Pakistan and the United Republic of Tanzania, account for more than 70 percent of the extremely poor. More than 400 million extremely poor people live in conflict areas, signalling the need to address poverty across the entire humanitarian and development continuum.

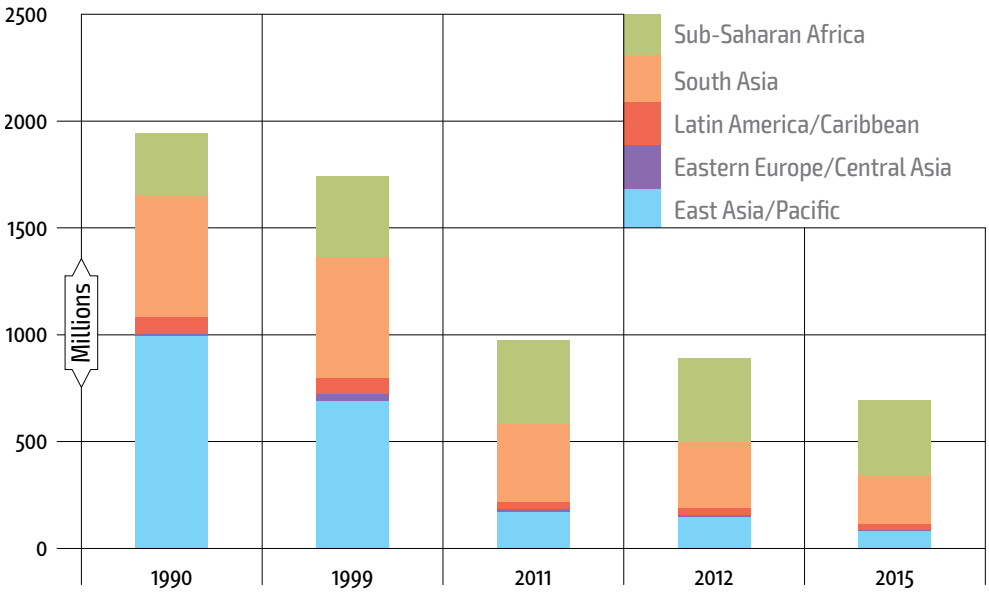
It has been acknowledged that the objective of pulling people out of extreme poverty by 2030 will not be achieved without actions to reduce inequality (World Bank, 2016, p.3). High inequality is impeding further poverty reduction, and economic growth, so far, has not been sufficiently 'pro-poor'.[1] This has hindered efforts to reduce the rates of extreme poverty and lower the risk that those escaping poverty will fall back into it. The lack of progress in poverty reduction is apparent when considering poverty *tout court*: despite economic growth and a reduction in poverty globally over

[1] Growth qualifies as more or less 'pro-poor', depending on the definition adopted. According to Kakwani, Khandker and Son (2004), absolute pro-poor growth materializes when, given a change in the national income, the poor receive more benefits in absolute terms than the non-poor. It is opposed to relative pro-poor growth, which occurs when, proportionally, the income of the poor increases more than the income of the non-poor; to trickle-down growth, which happens when, proportionally, the income of the poor increases less than the income of the non-poor; and to 'immiserizing growth', which results when, despite the growth of the per capita income, the income of the poor decreases. See Kakwani, Khandker and Son, 2004.

the last 30 years, about 2 billion people still live in extreme or moderate income poverty.

Extreme poverty is disproportionately concentrated in rural areas. The World Bank estimates that by 2010, 78 percent of the extremely poor were living in rural areas (Olinto *et al.*, 2013). This concentration of poverty in rural areas is common across regions, despite differences in overall poverty rates (FAO, 2015). Across all low- and middle-income countries, a person living in rural areas is almost three times more likely to live in extreme poverty than someone living in urban areas (World Bank, 2013). This relative deprivation among rural people is reflected in a wide range of socio-economic welfare indicators. For example, child malnutrition, as measured by the prevalence of underweight in children under five years, is worse in rural areas in virtually every country for which data are available (FAO, 2015). Typically, access to health, education, and basic services is also significantly better in cities.

Figure 8.1 People below the poverty line (PPP) of US$ 1.90 per day, 1990–2015



Note: Data for the Near East and North Africa are not available.
Source: FAO Global Perspectives Studies, based on World Bank, 2015.

Agriculture is key to poverty and hunger alleviation in rural areas, but is no longer enough

Most of the world's poor and hungry are rural people who earn meagre livings from agriculture, fisheries and forestry. Rural people in most low-income countries rely on agriculture for an important share of their incomes; in some regions, income from agriculture often represents the largest share of household earnings. Family farms are the backbone of agriculture in low- and middle-income countries. Almost 75 percent of these farms, around 375 million, are smaller than one hectare (FAO, 2014). They engage almost 75 percent of the economically active rural population and produce a significant share of the farming family's food.

Lifting the incomes of the rural poor above the extreme poverty line in sub-Saharan Africa would require an average increase in income of at least 60 percent above the estimated average income of the poor in 2010; in Asia (particularly in China and India) at least a 30 percent increase would be needed (Yoshida, Uematsu and Sobrado, 2014). For the poorest, these income gaps are even larger. On an annual basis, implied per capita income growth would need to reach 3 percent to raise average incomes by 60 percent between 2015 and 2030, and by 4.4 percent to double the incomes of the 'most poor'. These increases in per capita income are higher than those achieved in most low-income countries over recent decades and higher than globally projected average income increases. Many of the poorest have seen even less income growth (Vakis, Rigolini and Lucchetti, 2015).

In this context, agricultural policies play an important role in pro-poor growth. They could support increases in productivity and profitability in a number of ways: for example by providing efficient extension and advisory agricultural services, improving coordination along value chains and ensuring that the weaker segments in the chain reap the benefits of the integration of agriculture into markets.[2]

However, pro-poor growth goes beyond agriculture. To date, the ongoing wider process of economic development has led in many instances to a reduction in the number of people engaged in agriculture, with consequent urbanization. Permanently reducing poverty involves actions that cut across both rural and urban areas, such as providing wide access to good quality education, promoting economic diversification in rural non-farm income-generating activities, supporting economy-wide job creation, increasing the saving and investment potential of the poor, and implementing adequate social protection mechanisms.

[2] This implies, for instance, the enforcement of principles for responsible investment in agriculture (CFS, 2014).

While global inequality is narrowing, within-country inequality is rising in fast-growing developing countries and high-income economies

Even in countries where poverty has been reduced, inequalities remain pervasive between rural and urban areas, regions, ethnic groups, and men and women. Growth is less efficient in lowering poverty in countries with high initial levels of inequality or where the distributional pattern of growth favours the non-poor. Income inequality affects the pace at which growth enables poverty reduction (Ravallion, 2004). Moreover, higher inequality undermines the resilience of societies to possible shocks in development patterns, and leave larger shares of the population vulnerable to poverty.

A recent World Bank report stresses that it is doubtful whether accelerated economic growth will be sufficient to eradicate extreme poverty by 2030, without reductions in inequality within countries. Between 1988 and 2013, global inequality – defined as inequality in income among all persons in the world, irrespective of the country where they live – fell from 0.697 to 0.625, as measured using the Gini coefficient, which takes a value of 0 when all incomes are equally distributed, and 1 in the case of extreme inequality when one person gets all income (World Bank, 2016).

Most global income inequality continues to be explained by income differentials between countries. In 1990, between-country inequality accounted for about 80 percent of overall inequality. By 2013, owing to rapid

growth of incomes in emerging low- and middle-income countries, this share had dropped to 65 percent. Most of the recent reduction in global income inequality derives from the convergence of income among countries, and is mainly due to rapid growth in India and China (see also Figure 8.2). By implication, within-country income inequality has increased in importance. Trends in within-country income inequality vary greatly across low- and middle-income countries. On average, however, inequality rose between 1988 and the late 1990s, then stabilized or declined (World Bank, 2016, p.69).

Although within-country income inequality is higher than it was 25 years ago, progress since 2008 shows that for every country in which inequality has widened, there were two countries in which inequality narrowed. There remains real concern over increasing levels of income inequality in high-income countries and the share of income controlled by the highest income earners. Both the Gini coefficient and the share of income appropriated by the top 10 or 1 percent have increased in many countries for which information is available (World Bank, 2016, p.69). It has increased by up to 5 percent since 1990 in most high-income countries. This includes European countries, where the Gini coefficient averages now 0.306, with Germany recording the lowest (0.289) and the United Kingdom (0.355) the highest. In the United States of America, it has reached 0.372, the same value as the Russian Federation (Dabla-Norris *et al.*, 2015).[3] In China, the Gini coefficient rose from 0.33 to 0.43, and in India it reached 0.35.

Regional aggregations and comparisons are not straightforward, given the heterogeneity of data sources and treatment. However, analyses based on existing information show that the mean Gini coefficient in East Asia and Pacific, South Asia and high-income countries increased between 1993 and 2008, but decreased in all the other regions, particularly in Latin America and Caribbean. However, inequality remains above average levels in Latin America and Caribbean, sub-Saharan Africa, and East Asia where the Gini coefficient stands at 0.48, 0.44, and 0.37 respectively (World Bank, 2016, p.86, Table 4.1).

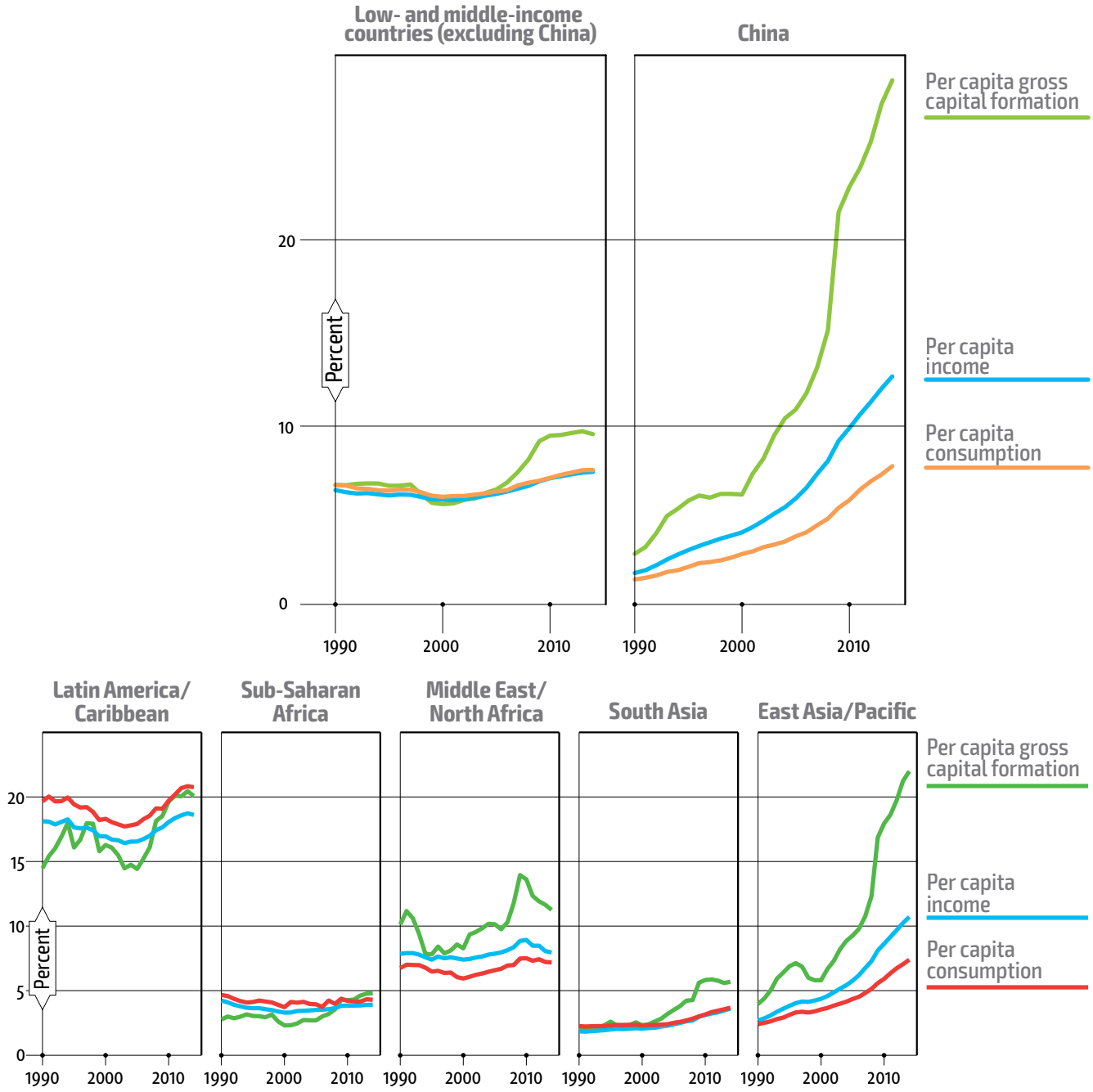
[3] Where 2012 data are not available, most recent data are used.

The evidence indicates that 'the rich are getting richer'. For example, in the United States of America at the beginning of the 20th century, the richest decile enjoyed slightly more that 40 percent of national income. After a period of decline, this figure returned to 40 percent at the end of the 1920s, and fell to 34 percent in the 1960s. Since then, the share has increased almost constantly, reaching close to 48 percent in 2010. A similar, but smoother pattern was followed by European countries, where the richest decile's share of national income rose from 29 percent in the 1970s to almost 35 percent in 2010 (Piketty, 2014).

An analysis of the income appropriated by the richest 1 percent in the United States of America since 1900 shows a clear U-shaped pattern. After decreasing from around 18 percent to around 8 percent in the 1970s, it sharply increased to around 18 percent in 2015 (World Bank, 2016). Japan and France displayed a similar pattern until 1970s, but since then the share of income of the richest 1 percent has remained between 8 and 10 percent (World Bank, 2016, p.69, Figure 4.2).

The share of income appropriated by the richest is rising in most rapidly growing countries, such as China, India, Indonesia and South Africa, where

Figure 8.2 Per capita indicators of low- and middle-income countries relative to high-income countries, 1990–2015



Source: FAO Global Perspectives Studies. Ratios calculated on values expressed in US$ at constant 2005 prices and exchange rates, based on UN, 2016.

the richest 1 percent appropriates 10, 8, 13 and 20 percent of national income, respectively. In the 1980s, the percentages were much lower (e.g. 5 percent in India and 6 percent in China) after a multidecadal trend of decreasing inequality (World Bank, 2016; Piketty, 2014).[4]

Are low- and middle-income countries catching up with high-income countries?

Given these trends in inequality, to what extent have the other low- and middle-income countries 'caught up' with the high-income group of countries in terms of per capita income, consumption and gross capital formation? What are the future perspectives for convergence, in the light of possible alternative futures for economic growth?

Figure 8.2 shows the ratios of per capita income, consumption and gross capital formation in low- and middle-income countries (excluding China) relative to high-income countries. In the past quarter of a century, the income and consumption indicators ranged between 7 and 8 percent of high-income country levels, while per capita gross capital formation has barely reached 10 percent. However, per capita gross capital formation in low- and middle-income countries (excluding China), relative to high-income countries has been trending upward since the mid-2000s. This positive trend is much more evident in China where, since 2000, significant progress has been made in per capita gross capital formation, which now approaches 30 percent of that of high-income countries.

Regional trends for the same indicators show that per capita consumption in Latin America and the Caribbean in 1990 was 20 percent of that recorded in high-income countries; 25 years later, it is still barely above 20 percent. In sub-Saharan Africa, the situation is even worse: per capita consumption levels have remained at just below 5 percent of the levels in high-income countries.[5]

Analogous trends apply to per capita capital formation, signalling the limited potential of capital endowments to improve this situation. Only East Asia, and to a much lesser extent South Asia, show some clear signals in the direction of convergence toward the levels found in high-income countries. It is uncertain to what extent this disparity in per capita gross capital formation across regions will be reflected in future asset ownership inequalities and consequent disparities in income, income earning opportunities, and human capital improvements across regions. However, it is likely to influence future economic growth patterns.

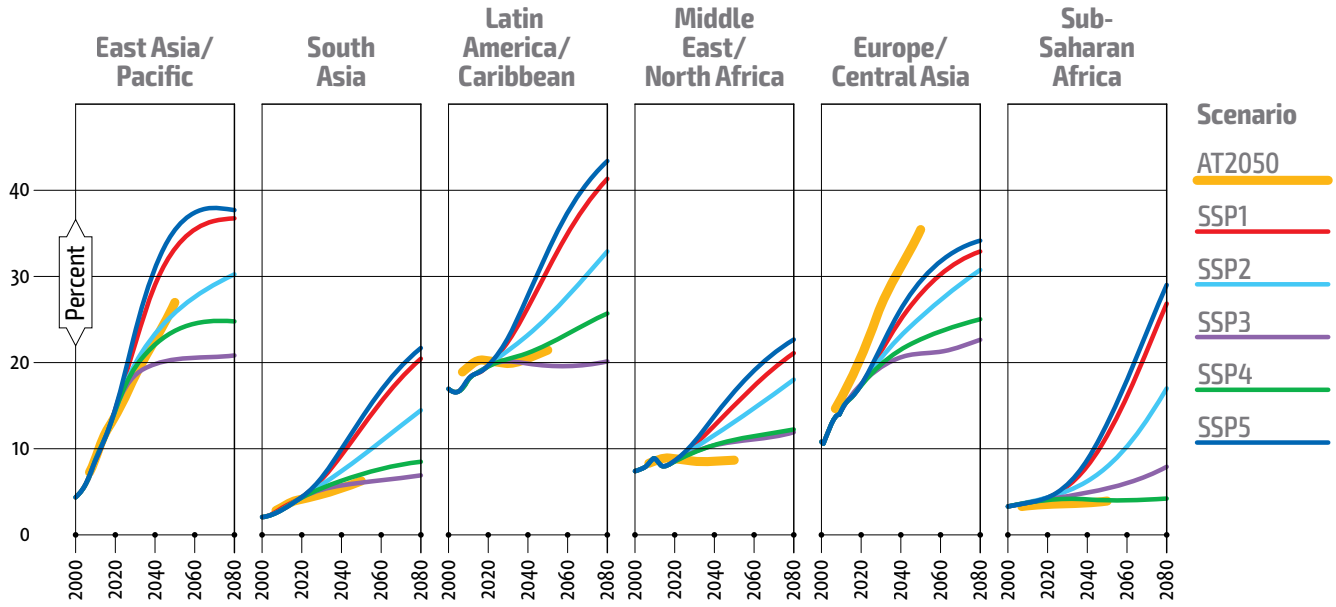
Recent GDP projection reflecting alternative possible futures – Shared Socioeconomic Pathways (see p.17) – as quantified by the OECD, suggest that even under the most optimistic scenario, and not before 2080, the per capita income of low- and middle-income countries (again, excluding China) would not reach 30 percent of the per capita income of high-income countries (Figure 8.3). More conservative estimates of per capita GDP growth in low- and middle-income countries, such as the ones assumed in the AT2050, do not exceed 10 percent of that in high-income countries, apart from China, which was projected to reach 35 percent.

Even if the recent trend of higher growth in low- and middle-income countries continues, absolute income differentials between groups may

[4] World Bank, 2016, p.76, Figure 4.2 for India, China and South Africa; Piketty, 2014 for Indonesia.

[5] Although these ratios are not expressed in purchasing power parity units, they depict a consistent long-term trend.

Figure 8.3 GDP per capita projections in low- and middle-income countries as a share of high-income countries



Source: FAO Global Perspectives Studies, based on IIASA, 2016 and Alexandratos and Bruinsma, 2012.

still widen. Converging income patterns may not eliminate substantial differences in the magnitude of income for many decades. The persistence of huge income differentials among groups of countries may continue to drive mass economic migrations, which may become unmanageable should they combine with distress migration. In addition, huge differences in gross per capita capital formation might feed inequalities in asset ownership, which is already extremely polarized. According to Oxfam, in 2016, just 8 individuals possessed the same wealth as the bottom half of the world's population (Oxfam, 2017), and polarization is even more extreme in Africa (World Bank, 2016, p.3). Inequalities in asset ownership may feed, in turn, future income inequalities particularly if poor people are not granted opportunities to earn decent incomes, save and invest.

If trends continue, the target of eradicating hunger by 2030 will not be reached

The State of Food Insecurity in the World 2015 estimated that in 2014–16, some 775 million people in the low- and middle-income countries were unable to acquire sufficient food to meet their daily minimum dietary energy requirements over a period of one year (Table 8.1). This means that 13.2 percent of these countries' population did not consume the necessary average food energy supply of 2 620 calories per capita per day (FAO, IFAD and WFP, 2015b).

Progress made towards the 1996 World Food Summit targets fell far short of the original ambition. Between 1990–92 and 2005, the number of undernourished fell by less than 70 million. The significant achievements made in East Asia (mainly China) were offset by little or no progress in sub-Saharan Africa and South Asia, where there are still high concentrations of undernourished people.

Table 8.1 Number of undernourished, 1990/92–2030

	1990-92		2000-02		2005-07		2014-16		2030	
	%	millions	%	millions	%	millions	%	millions	%	millions
High-income countries	< 5.0	32	< 5.0	36	2.2	29	1.6	23	1.1	16
Low- and middle-income countries	29.7	978	24.5	894	17.6	920	13.2	775	9.3	637
East Asia	28.2	432	20.3	339	15.9	311	11.1	233	7.8	175
Latin America	22.1	66	18.3	60	8.4	47	6.1	37	4.0	27
Near East	14.5	20	24.8	33	8.3	36	6.5	33	4.7	29
South Asia	25.1	284	19.0	258	20.5	311	14.9	257	9.3	188
Sub-Saharan Africa	45.9	173	40.4	201	29.0	212	23.3	213	17.4	216
World	18.6	1011	14.9	930	14.4	949	11.0	797	7.9	653

Note: The regional aggregation follows FAO, IFAD and WFP, 2015a.
Sources: FAO Global Perspectives Studies, based on FAO, IFAD and WFP, 2015a, b.

Between 2005 and 2015, greater progress was made. Nearly twice as many people escaped chronic undernutrition during the last decade compared to 1990–2005. However, even if the recent rate of progress continues, this would still be insufficient to achieve the World Food Summit targets. When extrapolated into the future, and assuming the same faster pace of progress attained over the past 10 years, the target of eradicating hunger by 2030, foreseen in Sustainable Development Goal 2, would not be met.

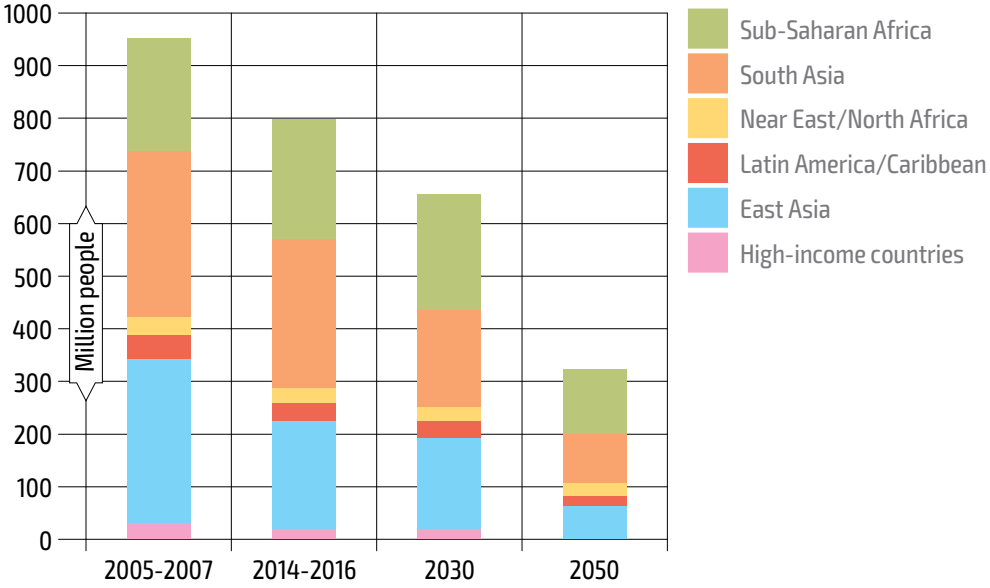
Progress in relative terms, i.e. reductions in the proportion of undernourished in the total population, has been more impressive. The prevalence of undernourishment fell by almost half between 1990 and 2016 in low- and middle-income countries (Table 8.1). This is close to the Millennium Development Goal hunger target, which was to halve the proportion of undernourished. Some regions, such as Latin America, East and Southeast Asia, the Caucasus and Central Asia, and North and West Africa, have made particularly fast progress. While progress was also made in South Asia, Oceania, the Caribbean, and Southern and Eastern Africa, the pace was too slow to reach the MDG target.

While overall progress in reducing the prevalence of hunger was driven by some very populous countries, it was not limited to these countries. A total of 72 low-income countries, out of 129 – or more than half of the countries monitored – have reached the MDG hunger target. Most of them enjoyed stable political conditions and economic growth, and often implemented social protection policies targeted at vulnerable population groups.

The most recent FAO projections of trends in undernourishment, provided in the report *Achieving zero hunger* (FAO, IFAD and WFP, 2015a), estimate the number of undernourished in 2030, under a 'business-as-usual' scenario, at 637 million people in low- and middle-income countries. This figure exceeds by 95 million people, or 17.5 percent, previous projections to 2030 reported for a mostly overlapping set of 'developing countries' in AT2050 (Alexandratos and Bruinsma, 2012). This signals that projections of undernourishment in 2030 in AT2050 may be quite optimistic, hence the last bar of Figure 8.4 should be interpreted with caution.

The number of undernourished projected in *Achieving zero hunger* definitely falls short of the SDG target of eradicating hunger by 2030. That is why FAO, IFAD and WFP call for a twin-track approach, which merges investment in social protection to immediately raise the food consumption

Figure 8.4 Undernourishment in a 'business-as-usual' scenario, 2005–2050



Source: Years 1990–92 and 2014–16 from FAO, IFAD and WFP, 2015a, b; year 2050 from Alexandratos and Bruinsma, 2012.

levels of the extremely poor, with pro-poor investment in productive activities to sustainably increase the income-earning opportunities of poor people.

Social protection directly contributes to the reduction of poverty, hunger and malnutrition by promoting income security and improving access to better nutrition, health care and education. By improving human capital and mitigating the impacts of shocks and crises, social protection also fosters the ability of poor people to participate in growth through increased access to employment.

Gender inequality in agriculture stifles productivity growth and threatens food security

As a distinct group, rural women experience disproportionately poverty and exclusion. Globally, and with few exceptions, rural women fare worse than rural men, and urban women and men, on every gender and development indicator for which data are available (UN, 2010). Women also face a higher risk of undernourishment – about 60 percent of people living in hunger are female. Addressing pervasive gender inequality will generate multiple benefits in terms of food security and poverty alleviation.

Women face particular barriers in access to productive resources, economic opportunities and participation in decision-making processes. Female farmers face a number of constraints in accessing agricultural inputs, services and markets that make it particularly difficult for them to rely on agricultural production as a pathway out of poverty (FAO, 2011; Quisumbing *et al.*, 2014). Women supply 43 percent of all agricultural labour in low and middle-income countries. This share reaches at least 50 percent in many countries in sub-Saharan Africa and elsewhere, especially where poverty is particularly entrenched and women have few other employment opportunities. They also tend to have poorer access to productive assets,

such as land and capital, inputs and technology, as well as services. Their decision-making capacity therefore remains limited, including in community decisions over natural resources.

Women's more limited access to productive resources is hampering productivity growth on smallholder farms and perpetuating income inequalities. In sub-Saharan Africa, the agricultural productivity levels of female farmers are between 20 to 30 percent lower than those of male farmers because of the gender gap in access to resources (FAO, 2011). Along with another trend, the feminization of agriculture, these burdens and constraints could have strong negative impacts on household food security and welfare in many parts of the world.

Women also face constraints on their use of time, often because of local norms and beliefs that affect their land rights, work stability and the type of activities in which they can participate. Women, for example, are heavily involved in collecting water and fuelwood, both for household consumption and agricultural use (Graham *et al.*, 2016). In 2010, an estimated 66 percent of households in sub-Saharan Africa, 55 percent in South and Southeast Asia, and 31 percent in Latin America relied on collected fuelwood for cooking, with women being primarily responsible for fuelwood collection.[6]

[6] On water collection, a recent study of 24 countries in Sub-Saharan Africa by Graham, Hirai and Kim (2016) found that among households spending more than 30 minutes collecting water, adult females were the primary collectors of water across all countries, ranging from 46 percent in Liberia to 90 percent in Cote d'Ivoire.

9 | Nutrition and health

Malnutrition comes in a number of forms that not only affect a person's health and well-being, but also place heavy burdens on families, communities and states (FAO and WHO, 2014). Ending hunger, achieving food security and improving nutrition are all key steps toward sustainable development (UN, 2016). Food safety is also a key concern, as unsafe food remains a major cause of disease and death (WHO, 2015). Meanwhile, changes in dietary patterns around the world have consequences for public health and sustainable development. As production systems become increasingly interconnected and the climate changes, the threat of food-borne, vector-borne, and transmissible zoonotic diseases increases.

'Triple burden' of malnutrition remains a global health emergency

The 'triple burden' of malnutrition weighing on most countries consists of undernutrition, micronutrient deficiencies, and overweight and obesity. Different forms of malnutrition can co-exist within the same country, the same household and even the same individual.

Undernutrition is declining globally. Between 2000 and 2015, the prevalence of stunting (low height for age) among children under five years declined from 32.7 to 23.2 percent, and the number of stunted children fell from 198 million to 156 million (UNICEF, WHO and World Bank, 2016). However, around 800 million people, or almost 11 percent of the world's population, still go hungry (FAO, IFAD and WFP, 2015b), and the rate of stunting is not declining fast enough, particularly in Africa, to reach the World Health Assembly target of a 40 percent reduction by 2025 (WHO, 2014). Childhood stunting is a largely irreversible outcome of inadequate nutrition and repeated bouts of infection during the first years of a child's life. Stunting before the age of two results in poorer cognitive and educational outcomes in later childhood and adolescence. In 2015, 7.4 percent of children under five were moderately or severely wasted (low weight for height) and, in 2013, an estimated 16 percent of all newborns globally had low birth weight (UNICEF, 2016).[1] Nearly half of all deaths among children under five are attributable to undernutrition (UNICEF, WHO, World Bank and UN, 2014).

[1] The low birth weight data refer to the period 2009–2013.

Micronutrient deficiencies affect more than 2 billion people worldwide (Micronutrient Initiative, 2015). In 2011, for example, more than half a billion women between the ages of 15 and 49 suffered from iron deficiency

anaemia. Anaemia contributes to 20 percent of all maternal deaths (WHO, 2016c), with about 50 000 women dying in childbirth each year due to a lack of iron. Vitamin A deficiency is a public health problem in more than 100 countries. It causes an estimated 250 000 to 500 000 children to go blind every year, and half of them die within a year of losing their sight (WHO, 2016d). An estimated 38 million babies are born with iodine deficiency, which is the most common cause of preventable brain damage (WHO, 2016b). Zinc deficiency affects about 30 percent of the world's population (Micronutrient Initiative, 2015).

Overweight and obesity are increasing worldwide, in all population groups, owing to increased consumption of foods that are high in energy, fats, added sugars or salt, and an inadequate intake of fruits, vegetables and dietary fibre. This 'nutrition transition' reflects rapid urbanization, the increased production of processed food, and more sedentary lifestyles. In 2014, some 40 percent of people aged 18 and over were overweight and, of these, 13 percent were obese (WHO, 2016e). Globally, 44 percent of adult diabetes cases, 23 percent of ischaemic heart disease and 7 to 41 percent of certain cancers are attributable to overweight and obesity (WHO, 2009). Almost two-thirds of the world's population live in countries where overweight and obesity kill more people than underweight (WHO, 2016e).

Between 2000 and 2015, the prevalence of overweight among children under 5 years rose from 5.1 to 6.2 percent (UNICEF, WHO and World Bank, 2016). If this trend continues, by 2025 the percentage of overweight, including obese, children under five will reach 11 percent, or 70 million (WHO, 2014). Childhood obesity increases the risk of early onset of obesity-related health complications, which were once thought to be only problems for adults. The early occurrence of these diseases can have serious consequences on children's future risk of non-communicable diseases (Park *et al.*, 2012). The economic price of malnutrition is billions of dollars in lost productivity and health care costs (FAO, 2013b). By improving nutrition, particularly during a child's first 1 000 days, many public health problems can be prevented and many obstacles to sustainable development overcome (1,000 Days, 2016).

Changes in dietary patterns are affecting public health

Dietary patterns are not only a reflection of what people eat; they reflect complex social behaviours. This makes assessment of what constitutes a healthy diet inherently difficult. Many factors need to be considered when undertaking interventions to encourage behavioural changes that can lead to healthier diets. For example, excess consumption of processed meat and red meat are linked to increased risk of death from heart disease, diabetes or other illnesses. At the same time, meat provides high-quality protein and a variety of micronutrients, such as iron, vitamin A, iodine and zinc, many of which are difficult to obtain in adequate quantities from foods of plant origin. Vitamin B12 is only found in animal source foods (WHO, 2016a). These nutrients are essential for a healthy immune system, which is needed to fight off infections. When addressing dietary patterns, the health risks and benefits of animal-source foods need to be balanced.

Between 1990 and 2013, the consumption of more nutritious foods increased worldwide. Trends differ, however, in the types of food consumed and across regions. For example, fruit consumption increased in all regions, but vegetable consumption increased only in some (Master, 2016). Typically, fruit consumption, in terms of grams per person per day, tends to rise with average income levels, whereas vegetable consumption declines. In sub-Saharan Africa, per capita fruit consumption was 16 percent below the global average level in 1990; by 2013, it had slipped to 23 percent below. In East Asia, instead, fruit consumption grew closer to world average levels – in 1990, it was 46 percent below; by 2013, it was 39 percent below. Seafood consumption in grams per person per day declined in three out of seven regions. It remains highest in Southeast Asia, which also saw the largest increase in whole grain consumption. Dairy product consumption is highest in North America and Europe.

These different patterns are partly due to differences in individual purchasing power and the income elasticities of food demand. They also depend on other factors, such as refrigeration options and access to convenience food, which tend to improve with levels of economic development. Cultural preferences also explain the different patterns across regions for meat, milk and fruit consumption.[2]

In most regions, however, the consumption of highly processed foods increased more than the consumption of fresh foods. Middle-income countries show the greatest shift toward dietary patterns based on highly processed foods (Imamura *et al.*, 2015). There was an increase in the consumption of sugar-sweetened beverages in four out of seven regions, with the largest increase in North America. In all regions, consumption of processed meat has increased. In East Asia, red meat consumption has increased substantially, but it has declined in every other region. Levels of red meat consumption are similar in East Asia, Latin America, North America and Western Europe.[3]

Data availability only allows for a systematic examination of long-term trends in dietary patterns using FAO's food balance sheets (FBSs), which provide evidence of apparent food intake through estimates of dietary energy supply (DES) and the per capita supply of protein. FBSs offer a comprehensive picture of long-term trends for key categories of food and provide globally comparable indicators of per capita daily food supply at the country level.[4]

An analysis by food groups reveals that in the last 50 years, per capita caloric availability and the diversity of foods consumed have increased (Figure 9.1a). Between 1961 and 2011, the share of calories from the apparent daily per capita consumption of cereals dropped from 35 to 29 percent in high-income countries and from 56 to 50 percent in low- and middle-income countries. During the same period, the share of calories from fruits and vegetables rose from 4.9 to 5.4 percent in high-income countries and from 3.9 to 6.9 percent in low- and middle-income countries (FAO, 2016b). FAO projects these trends to continue towards 2050, but with slower growth in the consumption of fruits and vegetables in low- and middle-income countries compared with that in high-income countries. The divergence in dietary transition towards more consumption of these nutritious foods is

[2] Based on Master, 2016. This paper uses data provided by the Global Dietary Database (available at www.globaldietarydatabase.org/the-global-dietary-database-measuring-diet-worldwide.html).

[3] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

[4] The DES in a country, or per capita food supply in kilocalories, as defined in the FBSs, is calculated as the supplies available for human consumption of each food element divided by the total population *de facto* present within the geographical boundaries of the country, times the kilocalories content of the food element. The per capita food supply is net of waste, defined (for FBS purposes) as the amount of commodity lost at all stages between the point where production is recorded and the retail level. Therefore, it is net of post-harvest losses, technical losses in processing (taken into account through extraction, conversion rates of products between different stages of processing), losses during storage and transportation and wholesale. Therefore, it is gross of the waste at retail and household level, including the discarding of inedible parts of the commodity during meals preparation. Food waste at the retail level is not considered in the practice of FBS compilation, contrary to the definition in the FBS handbook. See FAO, 2001.

largely explained by the projected strong increase in demand for meat and dairy products in low- and middle-income countries.

Overall, the average dietary energy supply in low- and middle-income countries remains well below that of high-income countries, but the gap is closing gradually. In 1961, the DES of low- and middle-income countries was only 68 percent of that in high-income countries, but rose to 81 percent in 2011. By 2050, it is projected to be 86 percent. Across all groups of food items, dietary patterns in the two groups of countries tend to converge – the ratios in Figure 9.1b are progressively getting closer to one, except for the ratio for fruits and vegetables (FAO, 2016b).

Figure 9.1a Per capita calorie intake by source, 1961–2050

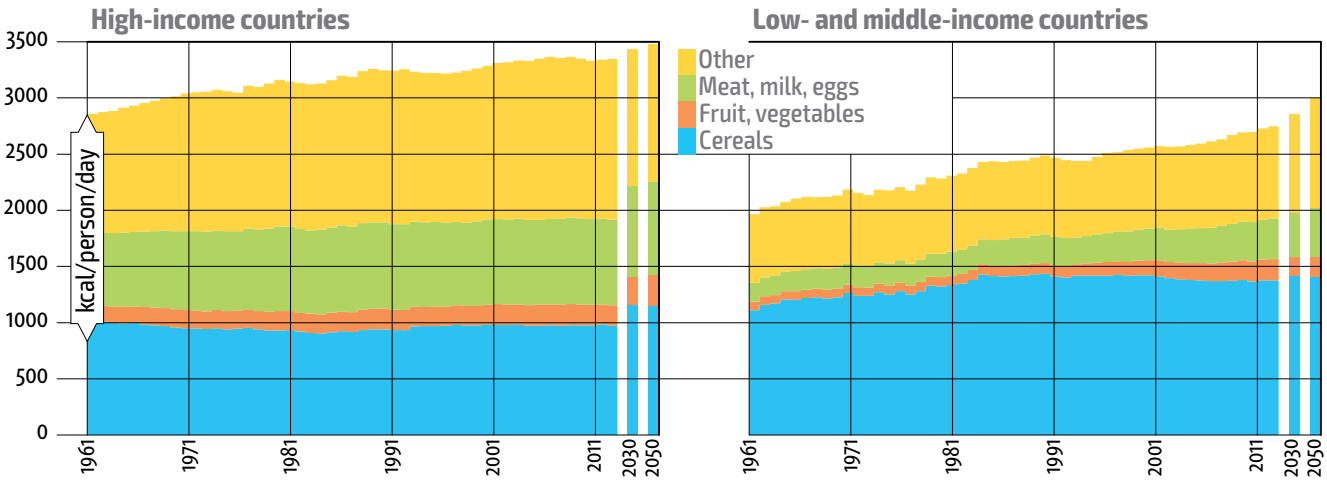
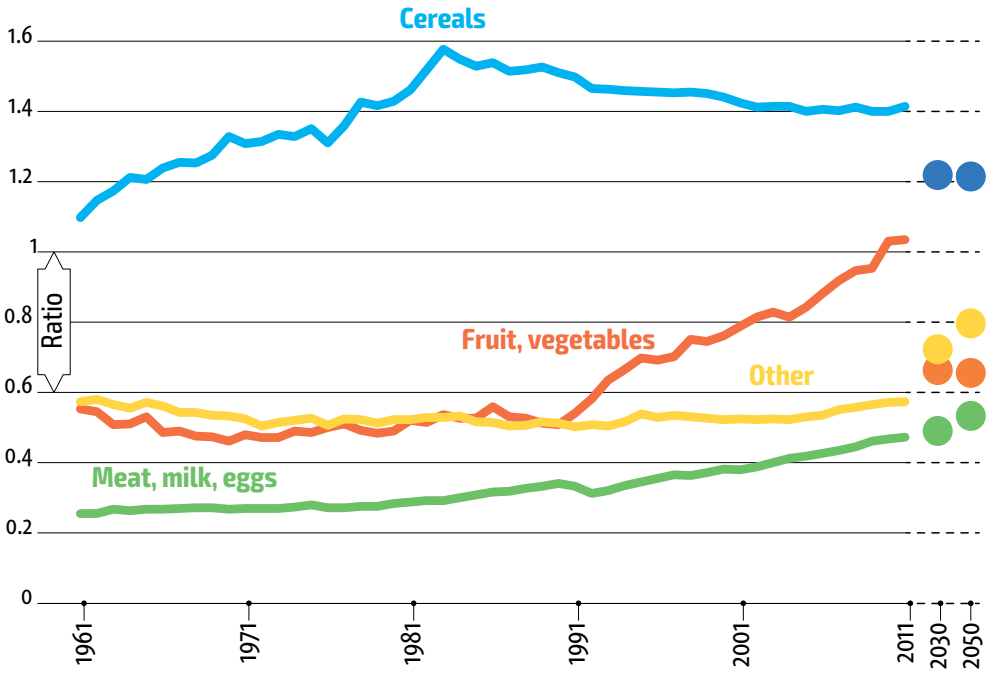


Figure 9.1b Per capita calorie intake in low- and middle-income countries compared to high-income countries



Sources: FAO Global Perspectives Studies. Data for 1961–2011 from FAO, 2016a; data for 2030 and 2050 from Alexandratos and Bruinsma, 2012.

Figure 9.2a Per capita protein intake by source, 1961–2050

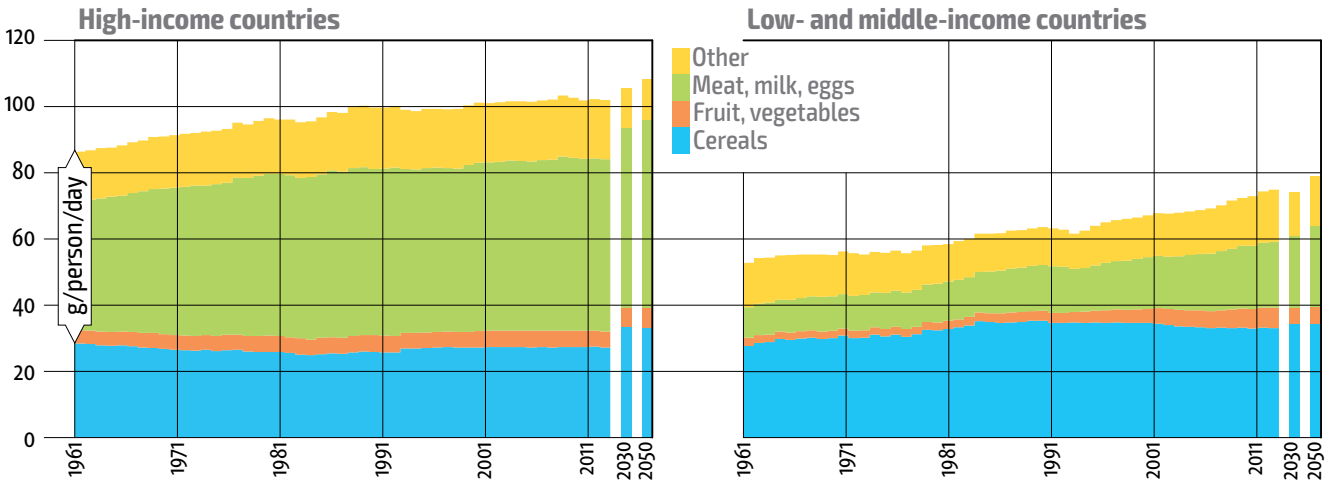
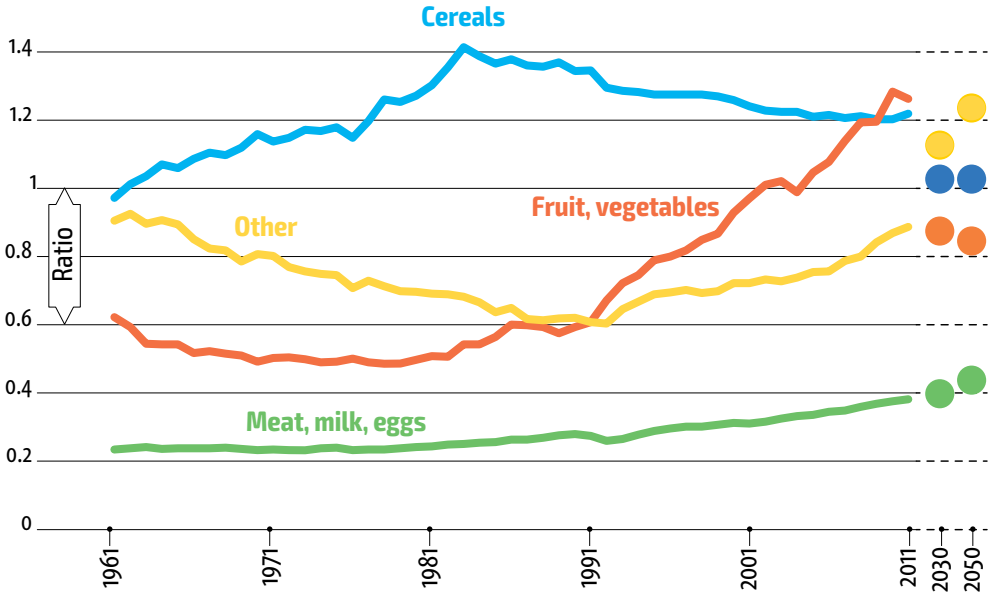


Figure 9.2b Per capita protein intake in low- and middle-income countries compared to high-income countries



Sources: FAO Global Perspectives Studies. Data for 1961–2011 from FAO, 2016a; data for 2030 and 2050 from Alexandratos and Bruinsma, 2012.

In the last 50 years, the daily intake of protein (Figure 9.2a) has increased in high-income countries, particularly from meat, eggs, milk and dairy products, which rose from 39 g per capita in 1961 to 52 g in 2011, a 33 percent increase for an annual growth rate of around 0.6 percent. Most of this increase occurred in the 1960s and 1970s. Since the 1980s, protein intake from animal sources has remained almost constant. FAO projections for 2030 and 2050 show daily protein intakes of 54 g and 57 g per person respectively. Between 1961 and 2011, in low- and middle-income countries, the daily per capita availability of protein from animal products rose from 9 to 20 g, an increase of 116 percent. The daily per capita protein intake from animal products in low- and middle-income countries is projected to reach 22 g by 2030 and 25 g by 2050 (Figure 9.2b).

Globally, fish contribute around 18 percent of the total animal protein intake, but in some coastal communities and small island states the percentage can reach as high as 60 percent (FAO, 2009). Global per capita consumption of seafood has been increasing and currently exceeds 20 kg per year. This trend is expected to continue as incomes rise and consumers become more aware that fish and fishery products can be a healthy alternative to meat from farm animals.[5]

With the increases in food supply in recent decades, the world now produces more than enough food to satisfy the dietary needs of the entire global population. The average DES per person per day in low- and middle-income countries is around 2 750 kilocalories and in high-income countries it is around 3 350 kilocalories. Both these figures exceed the minimum requirement of around 1 950 kilocalories per person per day (FAO, IFAD and WFP, 2015a, Table 1).[6] The same applies to protein requirements.[7]

However, adequate food availability does not automatically imply adequate food intake by all. First, inequality in incomes and other means of subsistence explain large differences in access to food and why still hundreds of millions of people are undernourished. Second, poorer households tend to face impediments to the adequate utilization of food owing to lack of access to facilities, such as food storage, cooking equipment and clean water, and to services, such as health care and basic nutrition education. Third, the dietary transition is partially reflected in improved access to more nutritious foods, including meat, dairy products, fruits and vegetables, but not necessary in the right balance. Analyses based on household surveys, as well as the trends shown above based on the FAO food balance sheets, suggest accelerated growth in consumption of meat and slower growth in consumption of fruits and vegetables.[8] This trend, together with rapidly growing consumption of processed foods, often with excessive quantities of salt, sugar, and preservatives, has given rise to concerns over the shift towards less healthy diets and the increasing prevalence of micronutrient deficiency and overweight.

If the benefits of the dietary transition observed in low- and middle-income countries are to continue in the future and bring about the achievement of the 2030 Agenda's nutrition objectives, some conditions may need to be fulfilled. While food production must keep the pace with increasing demand, equitable food access and adequate food utilization have to be ensured. In addition, consumer education is needed to promote healthier food consumption patterns and ensure that the food abundance experienced in high-income countries does not translate into poor nutritional outcomes.

Healthy diets contribute to a healthy environment

There is growing recognition that changes in nutrition are critical to achieving several of the Sustainable Development Goals. Dietary patterns should be scrutinized not only for their impact on health, but also for their impacts on the environment and particularly their link to climate change.

Diets rich in meat, particularly that of ruminants such as cattle, are associated with higher environmental costs and higher emissions of greenhouse gases: methane, resulting from enteric fermentation; carbon dioxide, which is released from the clearing of forests for pasture; and

[5] In addition to being a source of protein, seafood products deliver additional health benefits because they contain micronutrients and omega 3 fatty acids that are critical for the brain development of children under 5 and foetal development during pregnancy.

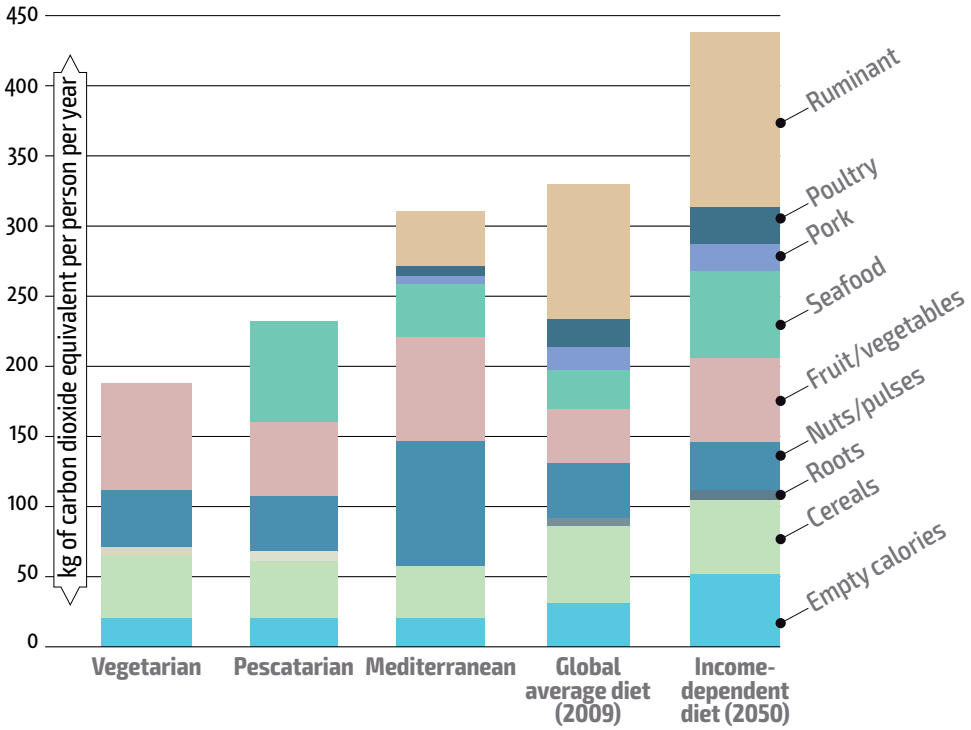
[6] Based on background data for FAO, IFAD and WFP, 2015b. See also FAO, 2008.

[7] Mean protein requirements in grams per day per kilogram of body weight range between 0.66 for adults to 1.12 for infants. An average adult weighing 70 kg would therefore require around 46 grams of protein per day. See: WHO, FAO and United Nations University, 2007, p.88, Table 4.

[8] The comparison between results from FBSs and household level data requires some caution. FBSs may tend to overestimate actual availability of food (Der Gobbo *et al.*, 2015). FBSs do not consider food losses and waste at retail and household levels. However, to reconcile results based on the two data sources no dramatic corrections of the overall consumption patterns resulting from FBSs are required. See Grunberger, 2014.

nitrous oxide, which is generated in feed production (FAO, 2013a; FAO, 2016c). Diets with lower intake of meat have significantly lower emission intensity (Figure 9.3). Industrialized livestock systems tend to generate fewer GHG emissions per unit of product than other livestock systems, but they have other significant social and environmental impacts, including higher withdrawals of freshwater, more pollution, greater use of antimicrobials with the associated risks of increased antimicrobial resistance, and potentially more outbreaks of zoonotic diseases.

Figure 9.3 Greenhouse gas emissions by diet type



Source: IFPRI, 2015.

In terms of GHGs emitted per unit of product, the aquaculture sector has significant advantages over other food production systems, especially livestock. Increasing evidence suggests that dietary patterns that have low environmental impacts can be consistent with good health (FAO and Food Climate Research Network, 2016). National dietary guidelines recommending lower red meat consumption, particularly among heavy consumers, could help reduce GHG emissions significantly (IFPRI, 2015).

Climate change is expected to also have direct impacts on food quality and nutrition. For example, the elevated levels of carbon dioxide in the atmosphere that are likely by 2050 are associated with substantial declines in the zinc, iron and protein content of wheat, rice, field peas and soybeans (FAO, 2016c). In addition, the higher temperatures and more extreme weather events associated with climate change create favourable environments for food- and water-borne pathogens (IFPRI, 2015).

Unsafe food remains a major cause of disease and death

Although comprehensive data on the extent of food-borne pathogens are lacking,[9] factors that contribute to outbreaks of food-borne diseases include: unsafe water used in food cleaning and processing; poor production processes and handling, including inappropriate use of agricultural chemicals; the lack of storage infrastructure; and inadequate or poorly enforced regulatory standards (WHO, 2015). Recent estimates show that, in 2010, some 30 global hazards caused a total of 600 million food-borne illnesses and 420 000 deaths. The most frequent cause of food-borne illness, which led to 230 000 deaths, was diarrhoeal disease agents. The global burden of food-borne disease was estimated at 33 million 'disability adjusted life years'. Some 40 percent of the food-borne disease burden was among children under 5 years of age, and the highest per capita burden was in Africa, followed by Southeast Asia and the Eastern Mediterranean.

Food-borne diseases are caused by bacteria, viruses and parasites, as well as chemicals and toxins, such as aflatoxins, peanut allergens, dioxins and cyanide in inappropriately processed cassava. The burden of aflatoxins is especially high in Africa, Southeast Asia and Western Pacific. Aflatoxins, which can cause liver cancer, are produced by mould that grows on stored grains, such as maize, as well as on groundnuts, oilseeds and tree nuts. Aflatoxins have also been linked to stunting in children (PACA, 2014).

Food-borne pathogens weaken immune systems. The most vulnerable groups are infants and young children, pregnant women, the elderly and people whose immune system is already compromised. In undernourished infants and children, food-borne diseases contribute to undernutrition by reducing the body's ability to absorb nutrients. Children who survive may suffer from delayed physical and mental development, which deprives them of the opportunity to reach their full potential in society (WHO, 2015).

As low-income countries adopt intensive animal husbandry to maximize production, the prevalence of pathogens in flocks and herds increases, as does the incidence of food-borne diseases. The warmer climate in tropical countries is also favours naturally occurring toxins and parasitic diseases.

Food-borne diseases slow economic development, and hinder the growth of the tourism, agriculture and food exports. Low-income countries' access to food export markets may be blocked if they are unable to meet the international regulatory requirements set by the Agreement on the Application of Sanitary and Phytosanitary Measures of the World Trade Organization. This, in turn, reduces the incomes of smallholder producers, which can impact their capacity to buy diversified and nutritious food.

Trade restrictions can also limit the availability of nutritious foods (Roesel and Grace, 2015). These food safety 'restrictions' on trade may come at a cost, in terms of market access for low-income countries, which may have more limited capacities to enforce food safety standards. Hence, the application of food safety standards in trade agreements may need to be supplemented by measures to assist low-income countries in strengthening national food control regulatory frameworks, enhancing food safety management along food chains, and developing online platforms for global networking and information sharing.

[9] The Rome Declaration on Nutrition of the Second International Conference on Nutrition reaffirms the right of everyone to have access to safe, sufficient, and nutritious food. It also highlights the need for legislative frameworks for food safety and quality to improve diets and nutrition and promotes participation in the activities of the Codex Alimentarius Commission in developing international standards and improving information for consumers.

10 | Structural change and employment

The development of countries may be seen as a process of change that transforms the structure of their economies. The structural change of economies can be measured by the dynamics of key features, such as the relative importance of sectors, the reallocation of factors across sectors and geographic areas, and changes in their productivity, which are associated with changes in consumer preferences, international trade flows and the social and institutional set up.

High-income countries, that once relied on primary production, especially agriculture, progressively shifted their economic systems towards industry and, later, service sectors. During this process, labour was reallocated while productivity increased in each sector and productivity differences among sectors declined. In low- and middle-income countries, income growth over recent decades has been characterized by the mobility of labour across economic sectors, within national territories and across international borders.

Where structural changes in production brought about improvements in income, a modification in consumption patterns occurred as well. This shift has been reflected in a number of ways, including dietary choices, the purchase of manufactured goods and the demand for welfare-related services, such as housing, education, health and security.

Demographic trends have determined the paths of structural changes in diverse ways. During the 1980s and 1990s, a range of policies and institutional changes related to infrastructure projects and trade liberalization were also influential. In many instances, these transformation processes brought about significant welfare improvements. However, concerns have arisen over their environmental and social sustainability, as well as the persistent inequalities within and between countries. Awareness of these issues is increasing, and the international community recognizes that there is an urgent need to put global and national development patterns on a sustainable track.[1]

[1] 'We recognize that fundamental changes in the way societies consume and produce are indispensable for achieving global sustainable development.' See UN, 2012.

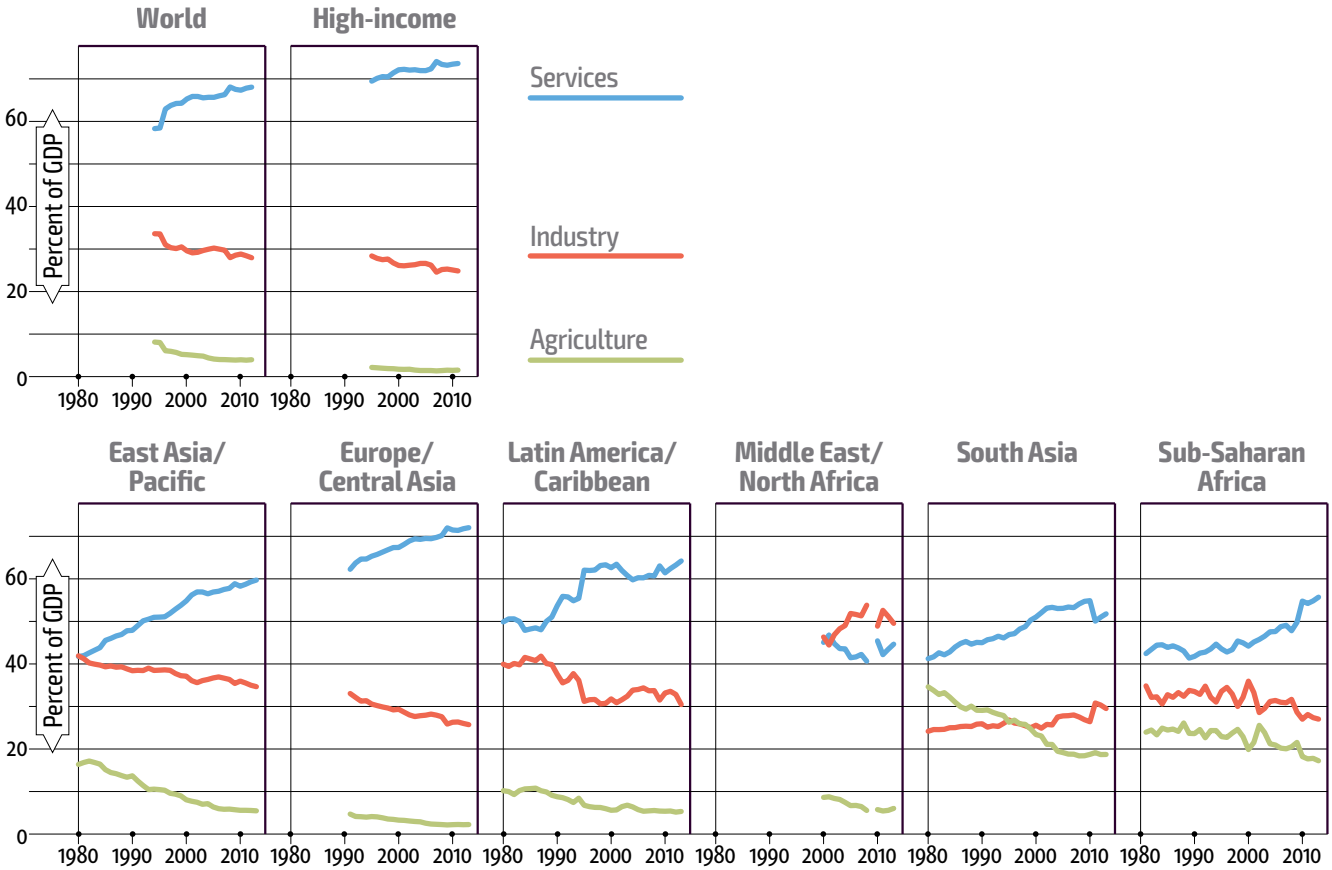
The speed and patterns of structural change and agricultural transformation differ across regions

In the conventional development paradigm, in order to develop, food and agriculture systems should become more capital-intensive, more productive, and better integrated with other sectors through markets. Small-scale farmers and members of their families would gradually diversify their

sources of income and employment, and – as development progresses – many of them would leave the agricultural sector entirely. This 'exit from agriculture' has taken place, for the most part, gradually over generations while land holdings are consolidated to gain economies of scale. Farmers who remain in the sector change their practices, shifting from multiple crops to monoculture, and moving away from staples toward higher value foods and cash crops. Risks that were previously pervasive are better managed, and the impacts of shocks are covered by insurance. Inputs previously produced on-farm and most food items for the farmer's family are increasingly bought through markets. Gradually, farmers are able to integrate into commercial food systems, earning higher incomes and employing better technologies. Other farmers exit agriculture and find job opportunities elsewhere (Binswanger–Mkhize, 2012; World Bank, 2009).

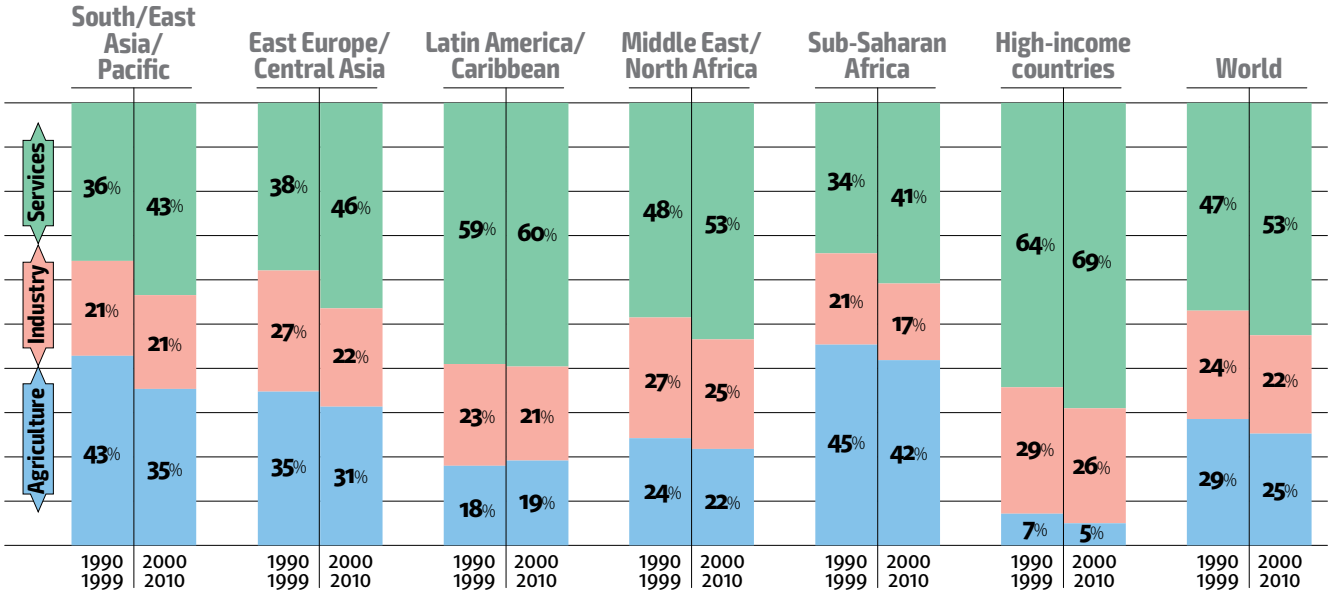
While country and regional experiences vary, such transformation patterns have been observed worldwide. Over the past 50 years, the relative contribution of agriculture to GDP decreased almost everywhere (Figure 10.1). To a lesser extent, agricultural employment shares also declined in the last 20 years (Figure 10.2). Economic transformation and the transition of the agricultural sector have given rise to rural towns and small urban centres, which are part of rural socio-economic development. This trend has been reinforced by stronger economic linkages between rural

Figure 10.1 Sectoral contributions to aggregate GDP, by region, 1980–2010



Source: Estimates based on data from the World Bank, 2016.

Figure 10.2 Sectoral employment shares, by region, 1990–2010



Source: Estimates based on data from the World Bank, 2016.

and urban areas, which have contributed to reducing poverty and, often, to closing the gaps between town and countryside in terms of quality of life indicators related to health, social welfare and livelihoods.

Expanding populations, income growth and urbanization have brought about quantitative and qualitative changes in the demand for food, which has propelled the development of agro-industrial production and market chains. The development of these chains has implications in a number of areas, including the allocation and use of natural resources, input factors and labour. Small and medium enterprises account for a large and growing share of the agricultural sector's value added and employment in low- and middle-income countries. Off-farm activities, such as handling, packaging, processing, transporting and marketing of food and agricultural products, provide multiple opportunities for employment. By increasing the demand for raw agricultural commodities, agro-industries help increase farmers' incomes (FAO and UNIDO, 2009). In many areas of sub-Saharan Africa, the value of agro-industries as a share of total manufacturing is significant, accounting for up to 60 percent in some countries (Roepstorff, Wiggins and Hawkins, 2011).

Due to the informal nature of agro-industries, evidence is scarce on the exact number of jobs the sector creates. However, there is evidence of high and increasing levels of female employment in the packing houses of high value chains (FAO and UNIDO, 2009). There has also been an emergence of agribusiness firms that integrate the manufacturing, distribution and retail stages of the food chain, which also affects demand and dietary patterns. Vertical integration occurs at the national level and across countries through the development of global value chains. The development of agribusinesses, of whatever size, influences the distribution of rents, the way that markets function, the formalization of production and marketing, and the diversification and differentiation of production (FAO and UNIDO, 2009).

The growth in demand for higher value-added commodities, processed products and pre-prepared foods is also providing stimulus to agro-industrial development in low-income countries (World Bank, 2013a). However, inadequate infrastructure and poor enabling policy environments often hamper dynamic agro-industrial development (FAO, 2011; FAO, 2014a).

Structural transformation, the transition of the agricultural sector and the consequences of these changes in terms of overall welfare, are specific to each country and region. They depend on initial conditions, demographic trends (population growth, urbanization, bulges in the youth age bracket, ageing and migration), geography, natural resource constraints, competition for water, land and forest resources, environmental threats, agricultural labour shortages and surpluses, changing dietary patterns, and policies and strategies. Regional comparative evidence and studies of structural transformation are presented in Box 1.

Urbanization has a unique role in reshaping the rural landscape. Where rural townships and medium-sized urban centres are better developed, agricultural and non-agricultural jobs tend to be created and poverty declines. Rural transformations in these contexts are shaped by the interaction of 'two middles'. One is the 'hidden middle' of rural societies, which refers to the rise of rural towns, which provide the most dynamic motor for socio-economic growth by creating higher demand for goods, services and food. The other is the 'middle segment' of the food system – the stages of the system that come after primary production and before consumption, such as trading, processing, packaging, distribution and storage (Christiaensen and Todo, 2013; Dorosh and Thurlow, 2014).

However, in some instances, these transformation processes materialize at a very slow pace and present social and environmental drawbacks, which challenge the conventional development paradigm. Especially in Africa and South Asia, land consolidation has not yet occurred, and, in fact, average farm sizes have become smaller through fragmentation. In other cases, labour mobility and young people's unwillingness to remain in the sector lead to increases in the average age of farmers, and stagnant or lower yields and productivity. In many cases, whatever the type of sectoral transition, the unequal distribution of resources, especially capital, may result in less efficient outcomes and, occasionally, in social tensions.[2]

All this has implications in terms of what is produced, how it is produced, the level of productivity in agriculture and other sectors, as well as the expected socio-economic and environmental outcomes of these transformation processes. On the one hand, the high population growth associated with a very high pace of urbanization in some countries makes it unlikely that all people exiting agriculture will find off-farm decent employment or other earning opportunities. On the other hand, energy and chemical-intensive production processes often associated with commercialization of agriculture raise concerns about environmental sustainability.

These factors, which may impede a smooth and sustainable structural transformation and affect food security, poverty and inequality, deserve careful policy responses.

[2] To some degree the so-called 'Arab Spring' refers to these issues. See Fox, Thomas and Haines, 2015; Acemoglu, Hassan and Tahoun, 2014.

Box 1 Experiences in structural transformation

This section is based on papers presented at an FAO conference on 'Rural transformation, agricultural and food system transition: Building the evidence base for policies that promote sustainable development, food and nutrition security and poverty reduction', held in September 2016 at FAO headquarters in Rome.

Southeast Asia[a]

Countries in Southeast Asia are diverse economically, socially and culturally. Most have undergone accelerated transformations, but with marked differences in the speed and the nature of agricultural change, depending on geography, natural resources, social factors, land scarcity and policies. Generally, the Green Revolution brought a rapid increase in output and yields of rice and wheat, which boosted small farm productivity and profits. Farms became commercial but also smaller because of population growth. Overall, labour productivity in terms of value added per worker has increased by 23 percent (Figure 10.3). Government investments and strong support for smallholder agriculture and agrarian reforms until the late 1990s paved the way for other industries to develop. Most of the region's GDP growth was driven by the services and industrial sectors. Even though land is scarce and average farm size quite small, the agricultural sector still employs a high share of the population, ranging from 13 percent in Malaysia to 71 percent in the Lao People's Democratic Republic. Nevertheless, employment in agriculture is following the downward trend in agriculture's share of GDP. This movement in labour is also due to rapid urbanization.
Although agricultural transformation was rapid in earlier decades, further productivity growth and structural transformation may be limited by insufficient absorption of the work force in productive activities and stagnant or declining rural wages. Although economic growth has helped to reduce poverty and improve food security since the early 1990s, with the proportion of undernourished falling from more than 30 percent in 1991 to less than 10 percent in 2015, vulnerability remains high. Many people live just above the poverty line and risk falling back with even small shocks to their livelihoods. Climate change, natural disasters and low public health spending also contribute to vulnerability. Rising inequalities, poor infrastructure and poor governance present additional obstacles to sustainable structural transformation, making the effort to eliminate hunger and poverty more challenging.

South Asia[b]

The economies of South Asia have seen strong growth in recent decades. Annual GDP growth rates have averaged about 7 percent over the past decade, compared with 5 percent in the 1980s and 1990s. Between 1970 and 2012, agriculture's contribution to economic output declined from 42 to 19 percent, while the contribution of the services sector grew from 38 to 51 percent. There was a modest decline in agriculture's share of total employment, from 59 to 47 percent between 1994 and 2012, mirrored by small increases in the employment shares in services (from 25 to 28 percent) and industry (from 16 to 25 percent). The speed and pattern of structural transformation differs between countries in the region, but thus far it has been slow compared to East Asia. Services sectors have become predominant, while no mature manufacturing sector has developed. As a result, the region lags behind in terms of the shift from low- to high-productivity employment. In India, the share of agriculture of GDP fell gradually from 29 to 18 percent between 1990 and 2012. However, the sector still employs almost half of the work force, 47 percent, down from 61 percent in 1994.
Agriculture still employs most workers in Bangladesh, Bhutan and Pakistan, with shares ranging from 44 to 62 percent, even though agriculture's share of GDP has fallen more significantly. Falling shares of agriculture in GDP, while large numbers of people still work in the sector reflects low rates of growth in agricultural labour productivity. In India and Nepal, agricultural value added per worker was stagnant and even declined between 1990 and 2011. In Bangladesh, however, growth in average agriculture value added per worker was higher, at 3.7 percent a year, during the same period.
Despite the slower structural transformation process, poverty and hunger have fallen significantly in the region. Between 1990 and 2012, South Asia's poverty rate fell from 51 to 19 percent, and the prevalence of undernourishment from 25 to 16 percent. The Maldives, Nepal, Pakistan and Sri Lanka were the most successful in reducing poverty. Bangladesh and India had the region's highest poverty rates, 44 and 21 percent respectively. Rising inequalities, however, have slowed the process of reducing hunger and poverty.

Latin America[c]

Agricultural income growth and changes in the structure of the agricultural sector have been associated with policy reforms. But evidence indicates heterogeneous transformation paths. In some countries, employment in agriculture grew more rapidly than the sector's output, resulting in declining labour productivity over the past decade (Figure 10.3).[d]

The region experienced strong economic growth, averaging around 6 percent a year, during the 1960s and 1970s, but significantly lower rates, of 3 percent, during the 1990s and 2000s. Pathways of structural transformation and agricultural transition diverge across countries. In Brazil, support policies helped to create a highly commercialized farm sector, and labour productivity in agriculture increased more than four times.[e] Agriculture's share of GDP has been about 6 percent for the past 20 years, while the share of agricultural employment declined from 24 to 9 percent.

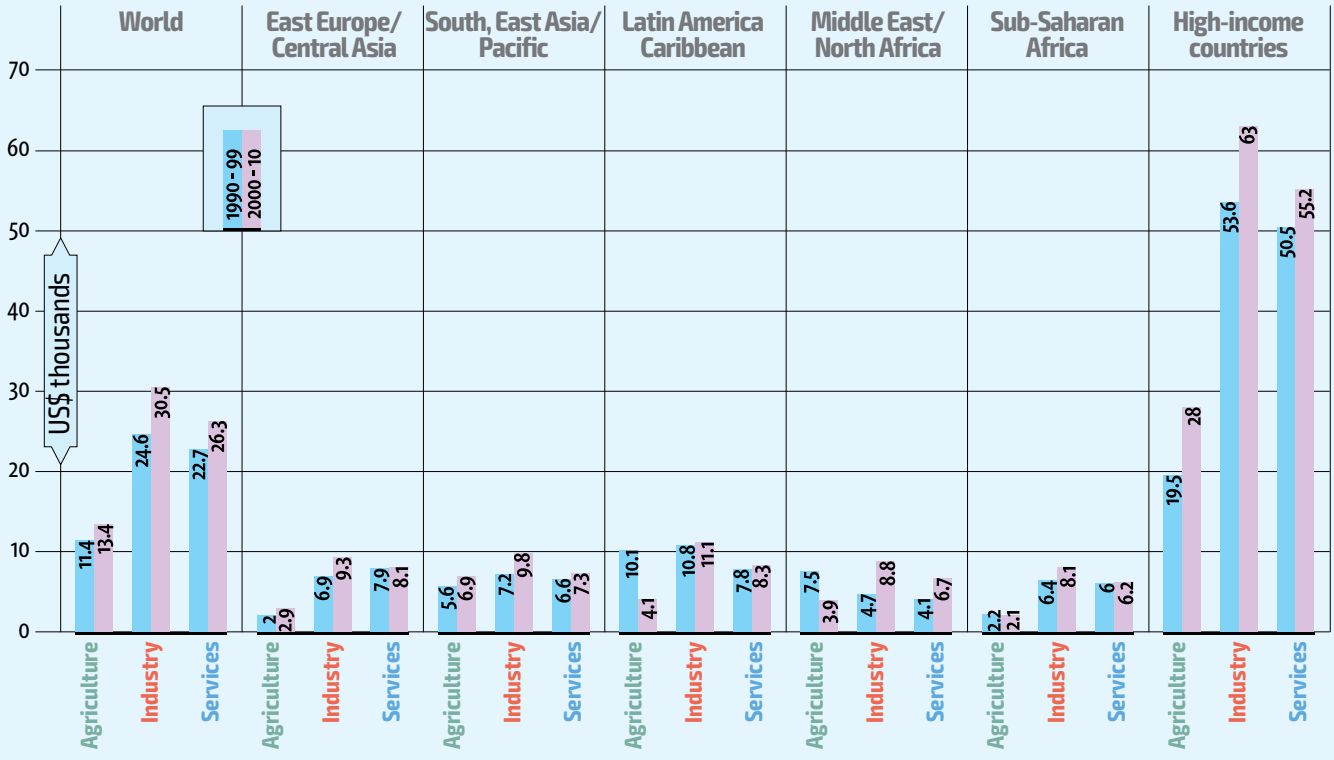
In Mexico, between 1990 and 2013, agriculture's share of GDP fell from 7 percent to 3.5 percent and its employment share by half, from 12 to 6 percent. Labour productivity nearly doubled in both countries and more than quadrupled in Argentina.

Overall income and agricultural productivity growth contributed to declining poverty rates. However, in the early 1980s, 74 million of a total rural population of 124 million were poor, and 41 million could not meet their food needs. By 2010, the numbers were 62 million, 119 million, and 39 million, respectively. While some countries saw important reductions in rural poverty, most have not significantly reduced the absolute number of poor people. High-income inequality has impeded the sharing of aggregate income growth with the poor. Many countries have extensive safety nets and social protection programmes that provide income support to the poor and vulnerable, including smallholder farmers. These have helped accelerate reductions in food insecurity, malnutrition and poverty, while also contributing to reducing income inequality during the 2000s.

Sub-Saharan Africa

Despite recent decades of economic expansion, agriculture accounts for just over 60 percent of the region's workforce (AGRA, 2013), and the contribution of agriculture to GDP is virtually unchanged. Although improvements in institutions, policies and international trade may have contributed to high economic growth rates (Zedillo, Cattaneo and Wheeler, eds, 2015), productivity growth in agriculture is declining, both in absolute terms and relative to industry and services (Figure 10.3).

Figure 10.3 Sectoral value added per worker, by region



Note: Regional groups do not include high-income countries.
Source: Authors' calculations based on World Bank, 2016.

With the region's population expected to more than double over the next 35 years, more than 10 million people may enter the labour market every year. However, industrialization is weak and non-agricultural sectors with higher productivity are so small that, even if they expanded rapidly over the coming decades, they would be able to absorb only a limited share of jobseekers. A number of African countries seem to be going through a process of 'de-industrialization', with rising shares of employment in the services sector and informal activities and little growth of manufacturing production and employment.

Systems for land tenure and governance remain weak throughout the region. Only 10 percent of rural land is registered. Land tenure laws are incomplete and poorly enforced, and applicable legislation is non-binding. Transferring land titles costs twice as much, and takes twice as long, as it does in high-income countries. Weak policy and institutional frameworks lead to corruption, including in land administration. Women are 50 percent less likely to have access to land than men. Generally, title and inheritance rights are bestowed on male family members, although women remain the primary users of agricultural land in most communities (AGRA, 2013). These multiple constraints may make it difficult to replicate the success stories of structural transformation elsewhere.

Middle East and North Africa[f]

The region is afflicted by civil conflicts with huge international implications, along with a general lack of social and political stability, which impacts economic development and food security.

The dominance of the high-productivity, but labour-extensive, mineral resource sectors in most countries has affected productivity growth in other sectors, including agriculture. This has slowed more benign economic diversification and perpetuated high dependence on food imports.

Different paths of transformation and economic development are found between oil-exporting and non-oil-exporting countries of the region. In oil-exporting countries, industry is the major economic sector with increasing shares of GDP, whereas non-exporters rely heavily on growth in the service sector. Until about 2006–07, agricultural labour productivity increased in several countries thanks to improved technology and innovation. Thereafter, a downward trend began owing to an increase in the number of rural people engaging in agriculture and only slow growth in agricultural output. Israel was one of the few countries that gradually increased its output while the absolute number of its rural population engaged in agriculture decreased.

Economic characteristics and differences within the region and between resource-rich and non-oil-exporting countries show that, although structural transformation has occurred at different levels, natural resource constraints, such as limited availability of land and water, are responsible for the low contribution of the agricultural sector to domestic food availability, thus creating increasing dependency on food imports.

[a] Based on Dawe, 2015.

[b] Based on Dawe, 2015.

[c] Based on Anriquez, 2016.

[d] Strong reductions in agricultural labour productivity in Latin America and the Caribbean have been noted in Colombia, Ecuador, Guatemala, Jamaica, Paraguay, Peru, Saint Lucia, Suriname and Uruguay. However those that mostly influence the regional average are in Colombia, Ecuador, Paraguay and Peru. The trend requires further analysis at the country level, but data problems cannot be excluded.

[e] COAG, 2010 with calculations based on World Bank, 2016, for the period from 1980 to 2010.

[f] Based on Breisinger *et al.*, 2016.

In some instances, the importance of agriculture and related businesses in national economies and people's livelihoods may increase, in which case smallholder agriculture will continue to dominate in most rural areas. Where this occurs, productivity increases and poverty reduction will strongly depend on how these areas can connect with the wider economy, benefit from diversification and overcome the constraints they face in accessing resources, environmentally sustainable technology and markets. Social protection policies and safety nets would have an important role to play in making the sometimes painful transition easier for vulnerable smallholder producers, allowing them to increase their productivity, diversify their production systems and move, when possible and necessary, into other sectors of the economy.

Small-scale, non-farm enterprises can generate employment if legal and financial constraints are addressed

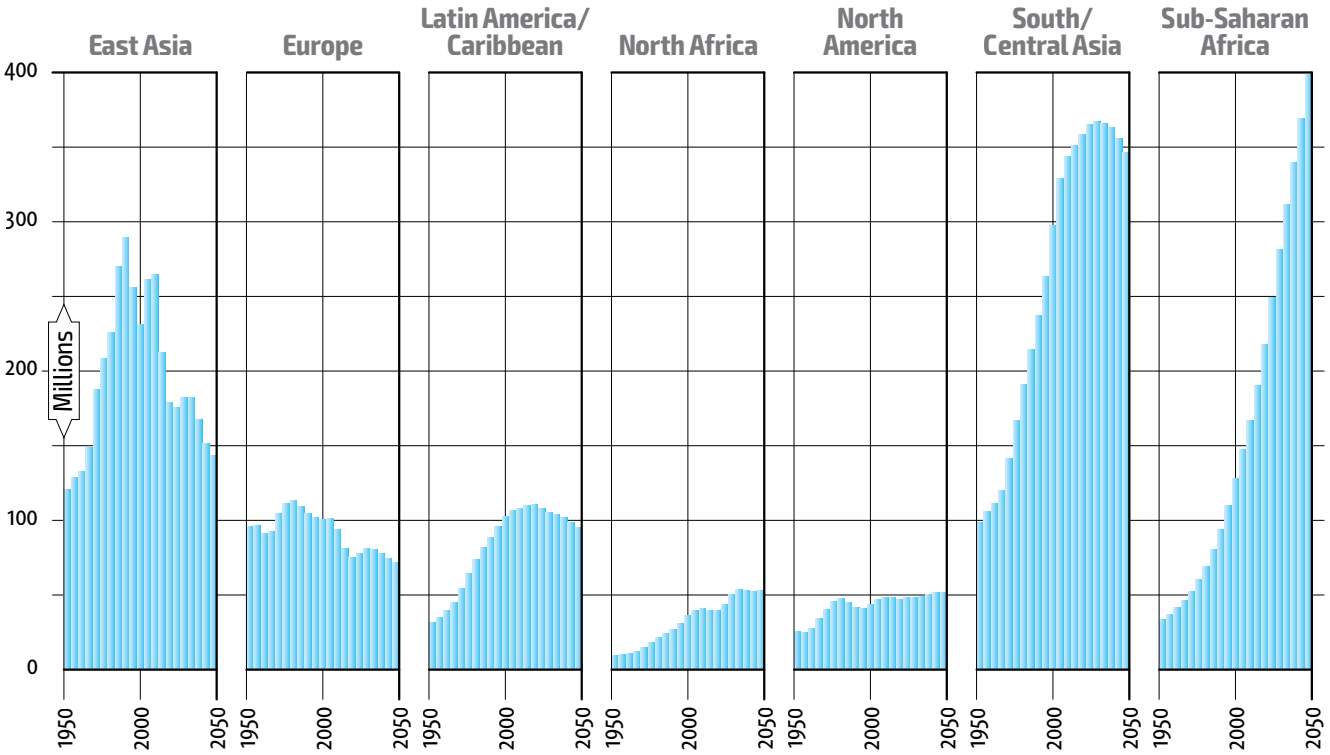
In low- and middle-income countries, today's young people are more educated than previous generations. However, their employment prospects are often bleaker, and their earning potential weaker, than those of their parents. Recently, young people in urban areas have expressed their discontent about their situation, for example during the Arab spring. Most rural people, especially the young, who tend to be less educated than their urban peers, also face declining prospects for stable and remunerative employment. There are more people between the ages of 10 and 24 living today than ever before. In some low- and middle-income countries, they make up a third of the population (World Bank, 2014; UNFPA, 2014).

Young people in these countries represent an opportunity for growth and development, especially given the ageing populations and low fertility rates in high-income countries. Most of the world's young people live in Africa and South Asia. These two regions will continue to have the highest concentration of young people in the years to come (Figure 10.4), and the average age gap between these regions and the rest of the world is expected to increase. If fertility rates continue to decline in Africa, the number of working age adults relative to dependents will increase from 1.0 in 1985 to 1.7 in 2050.

It has been estimated that, globally, some 620 million young people are neither working nor studying, and that 1.5 billion are working in agriculture and in self-employment. With around 10 million people entering the labour force every year in sub-Saharan Africa, and another 10 million per year in Asia, some 600 million jobs will need to be created globally between 2013 and 2030 just to keep employment rates constant (World Bank, 2013b). The labour supply may exceed demand in countries where the economy depends heavily on the minerals and mining sectors. Economic diversification through the expansion of agriculture, manufacturing, services and industry may help absorb available labour. The options for industrial wage-earning jobs vary by region.

Building human capital through effective basic and secondary education is crucial to youth employment. Today the average young Zambian and Ghanaian has more schooling than the average Italian or French person had in 1960. However, in many cases, because of substantial failures in

Figure 10.4 Estimates of the population aged 15-24 years, 1950–2050



Note: Each bar is an estimate or a projection of the number of 15 to 24 year olds for one year at five-year intervals.
Source: UN, 2015.

the delivery of educational services, including absenteeism, poor teacher preparation and teaching quality, schooling is not associated with actual skills training, education and learning (World Bank, 2014; Fox *et al.*, 2013).

There could be four major pathways for creating employment for rural youth: full-time work on the family farm; part-time farm work combined with off-farm household enterprises; agricultural wage-earning employment; and full-time off-farm household enterprises. Increasing demand for agricultural products may provide employment opportunities.

In most low-income countries, agriculture remains the major employer. Smallholder farmers are often caught in a trap of low earnings, low savings and low investments, which results in low levels of production and productivity. Small farm sizes and limited access to equipment and inputs prevent farmers from integrating into larger markets and taking advantage of economies of scale. Poor infrastructure, in terms of transport, access to electricity and irrigation, all serve to keep smallholder farmers in this trap. Higher food prices may boost productivity and create employment, but may also increase wage costs and lower competitiveness (World Bank, 2014). Addressing structural constraints remains the key priority for improving agriculture's capacity to create decent employment opportunities.[3]

Off-farm, small-scale household businesses provide productive and remunerative employment, when constraints arising from their informal status and lack of capital are addressed. In low- and middle-income countries, most of the population working outside the agricultural sector are involved in informal household enterprises. This is frequently part of

[3] Decent work has been defined by the ILO and endorsed by the international community as productive work for women and men in conditions of freedom, equity, security and human dignity. It is productive work that delivers a fair income, security in the workplace and social protection for families; better prospects for personal development and social integration; freedom for people to express their concerns, to organize and participate in the decisions that affect their lives; and equality of opportunity and treatment for all women and men. Decent work is a universal and indivisible objective, based on fundamental values and principles. (ILO, 2013; FAO, 2014b).

a diversified family strategy that combines rural farm incomes with urban wage-earning activities. Between 30 to 50 percent of rural households work in a non-farm household enterprise. Their productivity is low, but earnings are often higher than in agriculture or urban employment. Some small, mobile businesses sell food items in the city, where they compete with convenience stores, supermarkets and shopping malls. They often add value to goods or natural resources, or engage in artisanal activities and construction. Since these enterprises tend to remain small and acquire little capital, they have limited development potential.

Government policies tend to neglect non-farm rural household businesses. Occasionally efforts have been made to formalize them and convert them to small and medium enterprises. Their potential for employment creation is significant, especially in urban areas, if productivity and scale are considered (World Bank, 2014). Wage-earning small and medium-size enterprises that evolve from existing household enterprises may provide additional jobs if their efficiency increases and they can attract secondary school graduates. However, although this sector generates jobs at a fast pace, it will have difficulty absorbing the millions of young people expected to enter the labour force over the decades ahead, especially in Africa. Job creation could be achieved through export-oriented firms in agriculture, industries or services, provided proper institutions and governance mechanisms, such as the adoption and enforcement of the Principles for Responsible Investment in Agriculture and Food Systems, are in place (CFS, 2014).

To increase youth employment, new mechanisms are needed to provide essential services and improve technical knowledge and skills. Carefully planned entrepreneurial and technical training can be effective, while a range of institutions and instruments could improve access to credit, including: group savings and loan associations; chattel mortgages and leasing; and service bundles, such as contract farming. Incorporating household enterprises into planning generates income and employment by providing services such as electricity and transport. Small enterprises are willing to pay for these services through fees and taxes, although occasionally they pay higher rates than larger businesses (World Bank, 2014).

Ineffective land policies and insecurity of tenure due to missing land inventories and titling limit owners' investments in land and constrain productivity. Large commercial agricultural landholdings are contentious as they are often not transparent. Evidence shows they deliver poor results in terms of creating employment and generating revenues for the state (Liu, 2014). Infrastructure investments may have positive returns for development and poverty reduction, and can contribute to creating employment in agriculture and other sectors. But assessments are needed to select and prioritize interventions.

In many countries, the business climate, with its high costs of intermediation, bureaucracy, red tape and corruption, is far from conducive to development. For instance, evidence shows that Africa is not 'cost-friendly' for business. African firms spend about 20 percent more than firms in other regions in direct and indirect costs, and the invisible costs of corruption, security, red tape and power cuts (Iarossi, 2009).

11 | Migration and agriculture

Migration is a growing global phenomenon.[1] In 2015, the number of international migrants totalled 244 million, an increase of 41 percent compared to 2000 (UN, 2015). International migrants among the global population increased from 2.8 percent in 2000 to 3.3 per cent in 2015 (UN, 2015). The majority of these migrants, estimated at 150 million, are migrant workers, and about one-third are aged from 15 to 34 years (UN, 2011). Internal migration is even larger in scale. The number of internal migrants in 2013 was estimated at 740 million (IOM, 2013).

That a large proportion of migrants are rural people is revealed by the fact that around 40 percent of international remittances are sent to rural areas (World Bank, 2014). Male out-migration and the globalization of agrifood systems are among the key drivers of the feminization of agriculture, which is now under way in many low-income countries. In many parts of the Near East and North Africa, Central Asia, South Asia and Latin America, the female share of agricultural employment has increased significantly in recent decades (Slavchevska, Kaaria and Taivalmaa, 2016). The globalization of agrifood systems is also opening up paid employment opportunities for women outside of family farms.

Poverty, climate change and competition for natural resources are expected to fuel more distress migration

Of the world's quarter of a billion international migrants, nearly two-thirds live in Europe (76 million) and Asia (75 million). North America hosts the third largest number of international migrants (54 million), followed by Africa (21 million), Latin America and the Caribbean (9 million) and Oceania (8 million) (UN, 2015).

More than one-third of international migration flows from 'South' to 'North'. It is important to note, however, that South-South flows are even larger (Table 11.1). Migration often occurs primarily between neighbouring countries. In 2015, the majority of international migrants were living in countries in their native region in Africa (87 percent), Asia (82 per cent), Latin America and the Caribbean (66 percent) and Europe (53 percent). In contrast, most were born elsewhere in North America (98 percent) and Oceania (87 percent). The United States of America hosts the largest number of migrants (46 million), followed by Germany and the Russian Federation (around 12 million each), Saudi Arabia (10 million), the United Kingdom (8.5 million) and the United Arab Emirates (8 million).

[1] The legal definition of migration is ambiguous. The term 'migrant' is often used interchangeably to apply to refugees, economic migrants and those fleeing violence. Importantly, the status of a migrant is not defined and hence not recognized by international law. FAO uses the term 'migration' to refer to the movement of people, either within a country or across international borders. It includes all kinds of movements, irrespective of the drivers, duration and voluntary/involuntary nature. It encompasses economic migrants, distress migrants, internally displaced persons, refugees and asylum seekers, returnees and people moving for other purposes, including for education and family reunification (FAO, 2016a).

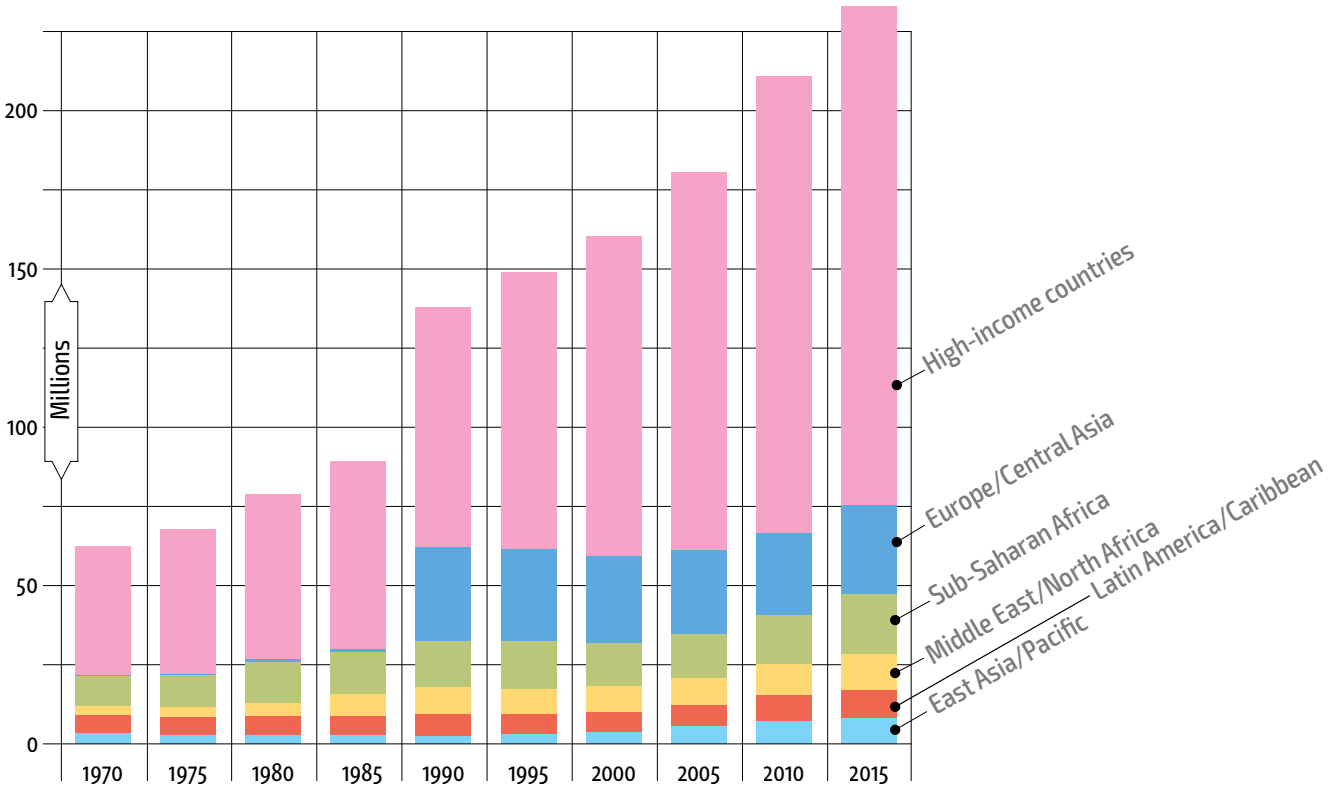
Table 11.1 Numbers of international migrants, by origin and destination, 2013

	Millions	Percent
Direction		
South > South	82.3	35.5
South > North	81.9	35.4
North > North	53.7	23.2
North > South	13.7	5.9
World	232.6	100.0

Source: UN, 2013.

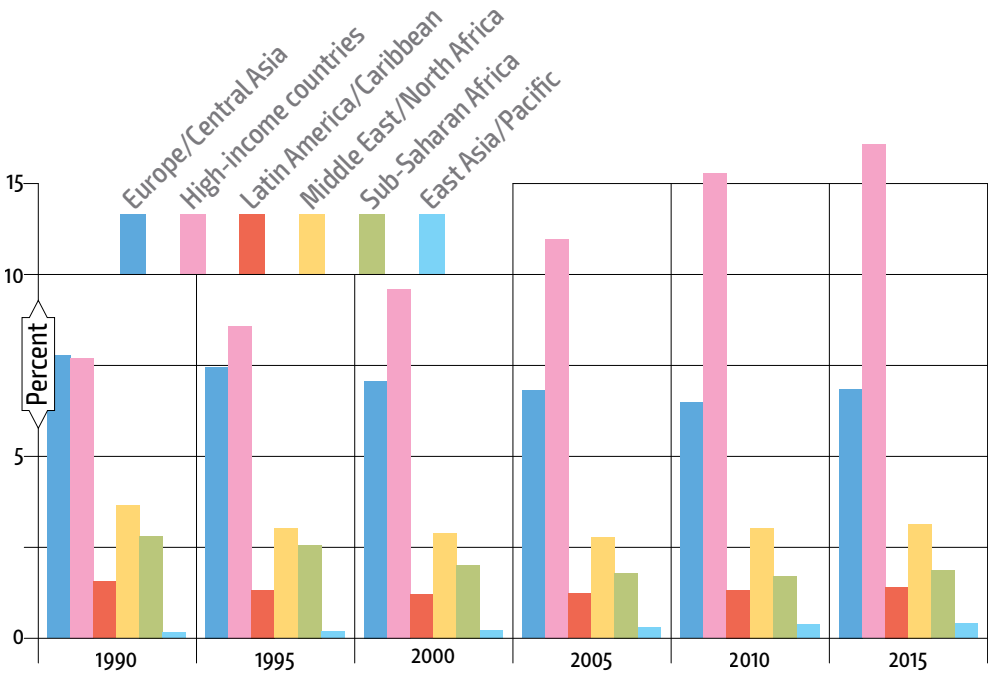
International migrants are an increasing and sometimes significant share of the population in destination countries (Figure 11.1). This is the case especially in high-income countries and in the Middle East and North Africa. Although migrants are slowly changing their destinations – with China, for example, becoming more attractive – high-income countries remain by far net recipients, and South Asia, East Asia and the Pacific are net sources of migrants (Figure 11.2).

Figure 11.1 International migrant stock, by destination, 1970–2015



Note: Regional groups do not include high-income countries.
Source: FAO calculations based on data from World Bank, 2016b.

Figure 11.2 International migrants in destination countries, 1990–2015



Source: FAO calculations based on data from World Bank, 2016b.

Migration is part of the development process. As economies undergo structural transformation, and the agricultural sector becomes relatively smaller, the movement of people within and across countries is inevitable. The total number of international migrants today has increased by more than 40 percent compared to 2000, and it is expected to reach more than 400 million by 2050.

Conflicts, violence and natural disasters are among the root causes of migration and forced displacement. However, many migrants are compelled to move because of socio-economic factors, including poverty, food insecurity, lack of employment opportunities, limited access to social protection, natural resource depletion and the adverse impacts of environmental degradation and climate change.

High rates of unemployment and underemployment are among the root causes of distress out-migration from rural areas (FAO, 2016a). Work in rural areas, and especially in the agricultural sector, is associated with low and insecure incomes, poor occupational safety and health conditions, gender inequality in pay and opportunities, and limited access to social protection (FAO, 2013).[2] Young men and women in agriculture often lack access to land, financial services and community decision-making. In addition, international migration flows have surged recently, especially from the Middle East, North Africa and sub-Saharan Africa, owing to conflicts, war or civil strife, growing resource scarcity and resource degradation, deteriorating livelihoods and food insecurity (FAO, 2016b).

While population growth is expected to slow globally, several countries are likely to face high rates of demographic growth. By 2050, the population of 13 countries could have more than doubled, from 320 million to 835 million, and could reach 1.8 billion by the year 2100. Should these projections

[2] As mentioned during the 2016 Youth Agribusiness, Leadership and Entrepreneurship Summit on Innovation (Dakar, Senegal from 29 to 31 March) youth are progressively abandoning agriculture, forestry and fisheries due to poor access to information, key services (e.g. education, health, transport, communication, leisure) and markets. They also have negative perceptions about farming, seeing it as antiquated and unprofitable and mainly as a subsistence activity. For more information see: https://www.ifad.org/stories/tags/senegal/17593915

materialize, larger out-migration appears unavoidable, particularly from resource-poor countries such as Mali and Niger.

Moreover, as all of these countries are projected to be adversely affected by climate change, migrant outflows are likely to intensify as the impacts of climate change become more severe. The combination of high population pressure and growing resource scarcity could create new conflicts, or add to existing conflicts, and reinforce the vicious cycle of population and resource pressure, conflict and protracted crises, and internal and international migration.

Social challenges can also emerge when populations in destination countries perceive migrants as competitors for jobs and a threat to wage levels. However, given the ageing population and low fertility rates in many high-income countries, migration could provide benefits for both destination and source countries.

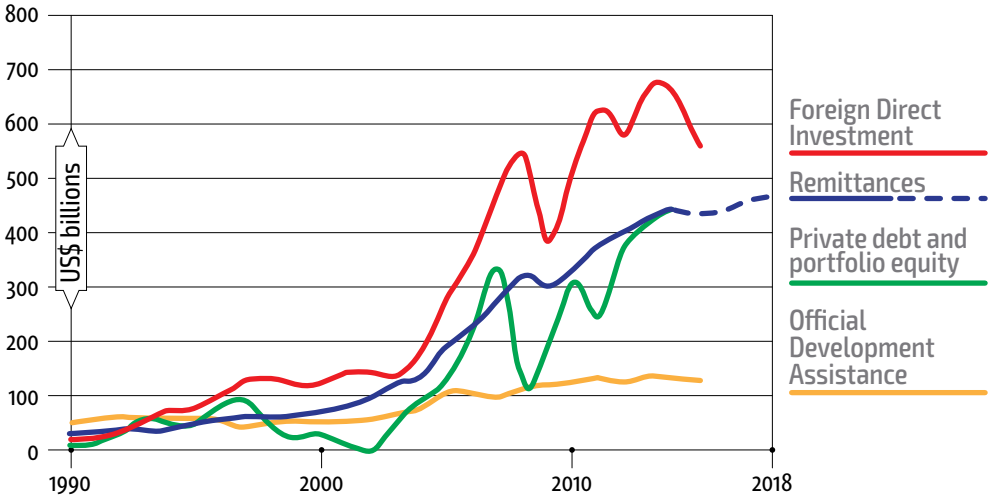
Migration brings both opportunities and challenges for the countries of origin, transit and destination.[3] In terms of opportunities, migration can reduce competition over land and water resources, foster a more efficient allocation of rural labour and create higher wages in agriculture. Depending on the context, women who stay behind may gain greater control over productive resources and services, potentially helping to close the gender gap in agriculture.

[3] For more references and county examples, see FAO, 2016c.

Moreover, remittances provide cash and insurance in case of crisis and shocks, and foster investment in agriculture and other economic activities that have potential for job creation. Diaspora organizations and return migrants can also help rural areas in countries of origin through capital investments, skills and technology transfer, know-how and social networks. Remittances also represent an important source of foreign exchange for recipient countries and, potentially, a significant means of development finance in some low- and middle-income countries.

Worldwide, remittance flows total around US$ 500 billion per year, more than four times Official Development Assistance (ODA) and close to both foreign direct investment (FDI) and private debt, which includes international bonds and borrowing through and portfolio equity commercial banks (Figure 11.3).

Figure 11.3 Remittances to low- and middle-income countries compared with other financial inflows, 1990–2018



Source: World Bank, 2016a.

However, because of migration, rural areas of origin risk losing the younger, most vital and dynamic part of their workforce. Migration of young men may cause ageing and feminization of rural populations and increased work burdens on those left behind. Especially when migrants encounter difficulties in finding decent jobs at their final destination or sending remittances to their families, women and children left behind can revert to negative coping strategies, such as taking on extra workloads to compensate for the income loss. In some cases, they might force children to work (Van de Glind, 2010). Migration can also increase inequality between recipients of remittances and non-recipients (Adams, 2011), and trigger changes in land use and titling, where remittances are used to convert agricultural land to land for housing (FAO, 2004).

Irregular or distress migration may be dangerous for the migrants themselves. Many challenges make mobility paths difficult and painful. In the job market, the means, skills, knowledge and networks of migrants are usually poor. Informal processes dominate, which causes efficiency losses for both people and countries in terms of foregone taxation. There are also social costs: dissatisfaction and unhappiness not only during the migration, but also when enduring difficult conditions and exploitation in final destinations.

The feminization of agriculture often increases women's burdens, but also presents them with opportunities

As agriculture adopts labour-saving technologies, agricultural employment is expected to shrink, with both women and men moving into other sectors. However, while men may diversify out of subsistence farming or out of agriculture altogether, women in many low-income countries may continue to work in agriculture. This has led to concerns about the feminization of agriculture.

A recent background review by the World Bank and FAO (Slavchevska, Kaaria and Taivalmaa, 2016) assesses the available evidence of the femini-

zation of agriculture globally. In many countries in the Near East and North Africa, Central Asia, South Asia and Latin America, the female share of agricultural employment has increased significantly in recent decades, and women have become the majority of those employed in the sector.

The trends towards agricultural feminization (Table 11.2) are especially prominent in the Near East and North Africa. Between 1980 and 2010, the share of women employed in agriculture increased from about 30 percent to 43 percent in North Africa, and from 35 percent to 48 percent in the Near East (FAO, 2011). Between 1980 and 2010, the female share in agricultural employment increased from 30 percent to more than 60 percent in the Syrian Arab Republic, and from 30 percent to 50 percent in Iraq and Morocco. The striking rise in women's responsibilities in agriculture is driven by demographic pressures and land fragmentation; the intensification of agriculture, which affects demand for male and female labour; jobs growth in other sectors; and social norms around women's responsibilities.

Table 11.2 Female share of economically active population in agriculture in 1980, 1995 and 2010 (percent)

	1980	1995	2010
Africa			
Burundi	55.9	55.9	56.0
Comoros	50.0	50.3	52.0
Madagascar	54.7	53.9	53.5
Malawi	56.7	56.1	59.2
Mozambique	58.6	63.4	65.2
Rwanda	55.3	56.1	57.0
United Republic of Tanzania	53.7	54.1	55.0
Zimbabwe	54.3	55.3	53.3
Angola	52.4	52.6	55.0
Chad	28.9	50.8	56.9
Congo	56.6	60	56.5
Botswana	46.6	52.4	56.9
Lesotho	72.0	68.2	67.3
South Africa	37.1	31.1	29.6
Swaziland	58.5	60.7	54.3
Benin	34.5	41.1	39.6
Gambia	50.6	51.2	53.3
Mauritania	47.6	49.2	53.9
Senegal	44.9	45.5	47.4
Sierra Leone	59.0	58.5	61.7
Algeria	41.5	50.4	52.7
Libya	37.2	50.0	69.9
Morocco	29.0	38.9	47.7
Sudan	32.5	32.9	39.5
Tunisia	27.1	34.4	32.8
Western Sahara	42.1	47.8	53.7

	1980	1995	2010
Asia			
Cambodia	57.3	54.9	51.2
Indonesia	33.7	39.0	39.3
Lao People's Democratic Republic	51.3	51.8	52.3
Viet Nam	50.7	51.0	49.1
Bangladesh	42.4	44.5	51.0
Bhutan	26.3	19.4	34.7
Iran (Islamic Republic of)	25.2	33.9	46.4
Nepal	35.4	42.2	48.1
Papua New Guinea	47.9	53.5	55.8
Pakistan	12.2	18.4	29.6
Western Asia			
Azerbaijan		53.8	53.9
Iraq	29.7	38.2	50.3
Jordan	41.9	44.3	62.2
Palestine	64.8	64.1	72.5
Syrian Arab Republic	31.7	50.7	60.7
Turkey	40.4	48.2	52.3
Yemen	29.3	31.4	40.1
Latin America			
Chile	9.2	10.6	14.2
Colombia	19.5	19.9	24.8
Ecuador	14.0	17.6	24.8
Peru	19.0	27.0	31.3

Note: Blue cells indicate increase since 1995.

Source: FAO, 2011.

The female share of agricultural employment is also rising in a number of countries in South and Central Asia. In Nepal, the share of women in the farming workforce increased from 35 percent in 1980 to almost 50 percent in 2010, and some sources suggest it may currently stand as high as 60 percent (ILO, 2016). Male out-migration is the key driver of the increasing role of women in agriculture in the country, since nearly all migrants from rural Nepal are young men. Women's share in agriculture is also increasing in Iran and Pakistan. Women formed only a quarter of Iran's agricultural workforce in 1980, but accounted for almost half in 2010. In Pakistan, from a meagre 12 percent in 1980, the female share in agricultural employment reached about 30 percent by 2010. Women are dominant in agriculture in some Central Asian countries as well. In Tajikistan, where deteriorating economic conditions in rural areas push men to migrate for work in neighbouring Russia, more than 55 percent of those employed in agriculture are female (ILO, 2016).

In most sub-Saharan African countries, women have always constituted a large part of the agricultural labour force, and there have not been significant increases in their share of employment in agriculture since 1980. However, there are exceptions. In Chad, for example, the share of women in agriculture increased from 30 percent to 57 percent over the past 20 years. In Botswana, women represented about 47 percent of the agriculturally employed in 1980, and 57 percent in 2010.

Growth in women's employment in agriculture is apparent in a number of Latin American countries, including Chile, Ecuador and Peru. In many countries of Latin America, the observed changes in women's engagement in agriculture are likely driven by wage employment in agribusinesses that produce non-traditional agricultural exports. Employment in these export businesses could facilitate women's economic empowerment and expand the number of jobs available to rural women.

While the globalization of agrifood systems is expanding paid employment opportunities for women outside of family farms, women working on commercial farms tend to be concentrated in labour-intensive, low-skilled jobs, and managerial positions are more likely to be taken by men (Dolan and Sorby, 2003), indicating the persistence of gender inequalities in the sector and insufficient gains in women's empowerment.

While the key drivers of the feminization of agriculture are male out-migration and the globalization of agrifood systems, there are other factors at play, including disease outbreaks, conflicts and climate change, which impact women's work in agriculture, both directly and as contributing factors to emigration and the availability of alternative employment.

The expanding role of women in agriculture can be empowering if women have a greater say in decision-making and the control of household resources. However, it may also exacerbate women's workloads, as infrastructure and institutions in low-income countries are rarely adapted to supporting working women. Successful migration and high remittances have the potential to boost agricultural production and women's empowerment, opening up new possibilities for women and youth in terms of livelihoods, economic roles and community leadership.

However, migration is not always successful, especially when urban areas cannot absorb the migrant population, and the migrants do not have the capital needed to overcome the financial constraints of migrating abroad. When remittances are inadequate, women face heavier workloads, financial difficulties and reduced welfare. This also reduces time for household work and child care (FAO, 2015).

The impact of migration on gender relations is complex and needs to be carefully accounted for in policies and programmes. Thanks to remittances, women can sometimes move from poorly paid and exploitative occupations to decent employment, or from unpaid subsistence agricultural labour to running small businesses (FAO, IFAD and ILO, 2010). In other cases, migration can reinforce traditional gender roles, as women are at high risk of finding jobs only at the lower end of market and face high barriers to integration at their destination (GMG, 2013). Even when women acquire more autonomy and decision-making power at the household level, this does not necessarily extend to social spheres, such as employment and their role within their communities.

12 | Changing food systems

Urbanization, the exit of labour from agriculture and a decline in agriculture's contribution to GDP have historically characterized the structural transformation of socio-economic systems. In today's high-income countries, this process led to the emergence of an urban middle class and a massive shift in food preferences towards meat and dairy products. Although evidence is still sparse and studies are ongoing, the same process appears to be occurring in low- and middle-income countries. At the same time, demographic pressure in these countries is increasing. Together, these dynamics change food systems in various ways, and these changes, in turn, drive further structural transformation.

While population growth increases the demand for agricultural products and stimulates farming activities, urbanization requires food to be easily stored and transported. Thus, food processing has become a key factor in the transformation of food systems. It has brought with it the standardization of agricultural output and, in many cases, the concentration of primary production and the consolidation of farmland. Many smallholder farmers have become landless agricultural workers, or have migrated to towns and cities in search of employment, accelerating urbanization.

Food production is changing along with retail channels

Agriculture and food production are increasingly supplying urban and peri-urban supermarkets. Value chains are progressively characterized by the vertical coordination, and in some instances the integration, of primary production, processing and distribution; the automation of large-scale processing; and higher capital and knowledge intensities.[1] A comprehensive global assessment of these transformations, particularly in the wholesale and retail segments of the value chains, is difficult, owing to the lack of easily accessible and comparable data. However, some trends by groups of countries and regions can be inferred from existing literature.

Between 2001 and 2014, the share of processed food distributed through supermarkets[2] significantly increased in upper middle-income countries, from less than 40 percent to 50 percent. In the same period, it grew from around 72 percent to 75 percent in high-income countries. In lower middle-income countries, it grew from 22 to 27 percent between 2001 and 2008, with no further change between 2008 and 2014 (Global Panel on Agriculture and Food Systems for Nutrition, 2016, p.93).

A different picture emerges for fresh food. Over the last 10 years, the share of fresh food distributed through supermarkets has remained below 50 percent in high-income countries, below 30 percent in upper middle-

[1] 'Vertical coordination' involves the establishment of some form of contractual relationship between the agents in subsequent segments of the value chain. Marketing contracts and production contracts are common forms of these relationships. Marketing contracts are agreements between a contractor and a grower that specify some form of a price (system) and outlet *ex ante*. Production contracts are more extensive forms of coordination and include detailed production practices, extension services, inputs supplied by the contractor, quality and quantity of a commodity and a price. The upper limit of 'vertical coordination' is 'integration', which involves the unique ownership of two subsequent segments. See FAO, 2007.

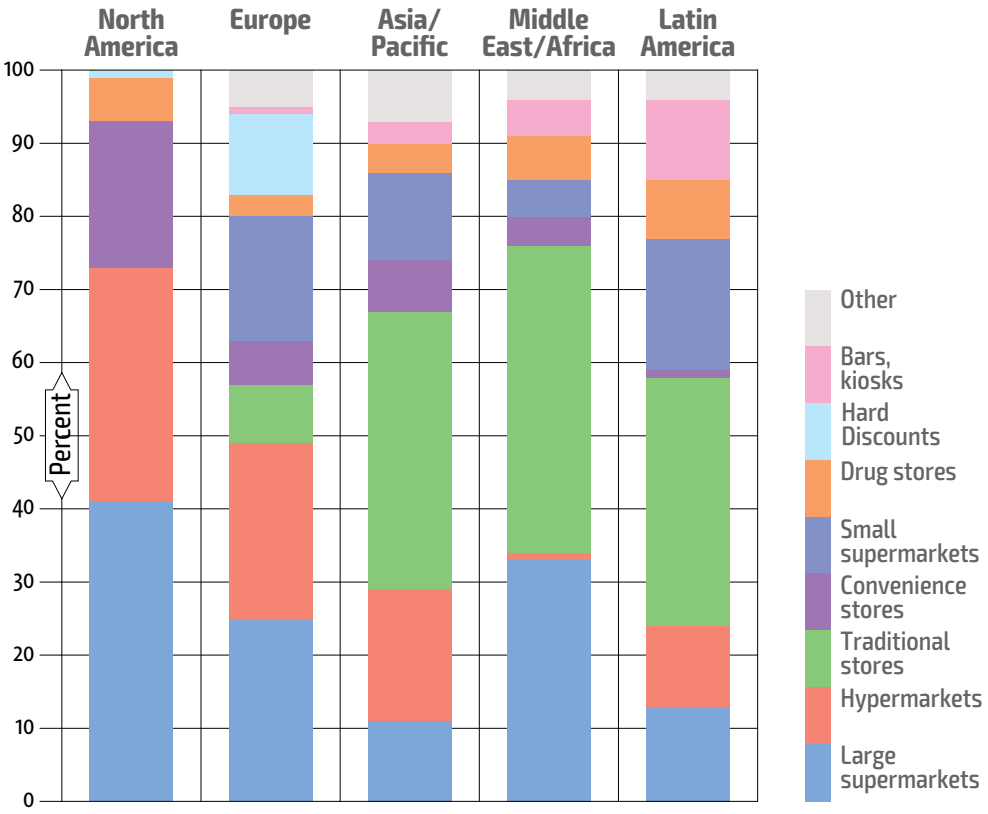
[2] The term 'supermarkets' here includes hypermarkets, supermarkets, hard discounts and convenience stores.

income countries and around 10 percent in lower-middle income countries (Global Panel on Agriculture and Food Systems for Nutrition, 2016).

However, global figures hide regional specificities. In Latin America, rapid urbanization has led to profound changes in food production and distribution systems, with supermarkets now accounting for more than 50 percent of grocery sales (Reardon *et al.*, 2014). In much of Asia, most food purchases in urban areas are now made in supermarkets. Even in East Africa, the share of purchased food in total food consumption is just below 60 percent (Tschirley *et al.*, 2015).

Hypermarkets, large supermarkets and convenience stores account for 93 percent of consumer purchases in North America but, as Figure 12.1 shows, play a much more modest role in Europe (55 percent), Latin America (46 percent), Middle East and Africa (38 percent) and Asia (36 percent). Another characteristic of Europe and Latin America is the existence of small supermarkets, which account for almost 20 percent of sales. It is difficult to say whether these small supermarkets, as well as traditional forms of commerce, will maintain their market share, or be absorbed by larger enterprises or evolve into other forms of distribution, such as hard discounts or large specialty shops. There is probably room for diversified forms of distribution, particularly in the light of emerging forms of e-commerce focused in the 'last-mile' of the distribution system (The Nielsen Company, 2015) and emerging preferences for ethical and ecological food.

Figure 12.1 Share of the food retail trade, by channel and region



Source: The Nielsen Company, 2015.

Vertically coordinated, capital-intensive value chains challenge small-scale farmers

While offering employment opportunities, the transformation of agrifood chains in low- and middle-income countries has, in many cases, created serious barriers to the participation of smallholder producers and small-scale agro-processors in local, national and global markets. Since they are more capital-intensive, agricultural production and supply processes require much less labour (Neven *et al.*, 2009). Barriers to smallholder access to supermarket channels, combined with reduced labour requirements, may undermine farmers' livelihoods if they cannot diversify into other rural off-farm activities. This may ultimately hinder rural transformation.

For many small-scale operators, issues of financing, market accessibility and transport, as well as the range of standards related to quality, traceability and certification make participation in integrated value chains difficult. The concentration of purchasing power in the hands of a few supermarket chains allows them to require that suppliers maintain large stocks (Timmer, 2014). This helps supermarkets to respond quickly to fluctuations in demand, which stabilizes prices. However, economic agents with weak negotiating power bear the cost of these market adjustments. Broader development policies would be needed to facilitate the transition to alternative employment for those who lose their livelihoods.

Smallholder farmers benefit from the transformation of food systems when they are able to join vertically coordinated value chains through fair contracts with processors and traders. In recent decades, a variety of business models, national and international value chain organizations, and institutional arrangements and policies have emerged to provide incentives and support services to smallholders, with the aim of increasing sustainable food production and facilitating market access (Rao and Qaim, 2011).

The innovations include institutional and market intermediaries, such as participatory guarantee systems, marketing cooperatives, training centres, private traders and local public procurement mechanisms, which take on a wide range of roles in linking farmers to markets. These arrangements tend to be more effective in linking smallholder farmers and small-scale processors to markets, the better the availability of local infrastructure and the stronger the producer organizations and related institutions.

Vertically coordinated value chains have far-reaching implications for dietary patterns, nutrition and health

In addition to improving the efficiency of food delivery systems, these value chains have helped improve food quality and safety, which benefits consumer health. At the same time, they have facilitated the diversification of diets among more affluent consumers, accelerating the shift from starchy staples, which are the main foods of the poor, to livestock products, fats and oils, and fruit and vegetables. More affluent consumers tend to adopt globally connected lifestyles that increase the demand for novel foods.

However, industrialized meat production processes and higher consumption of processed foods also raise concerns related to nutrition, the environment, food security and food safety. Large-scale food processing risks increasing the availability of cheaper foods that have a high content of

fat, added sugar and salt (so-called 'empty calories'). Recent studies of the links between people's diets and their food environments, i.e. the food that is made available, affordable, convenient and desirable based on consumers' tastes and education, have produced mixed findings. Sometimes, the wider availability of processed food leads to higher food consumption and greater dietary diversity. In other cases, low-income populations find it more difficult to adopt high-quality diets and are more likely to consume 'empty calories'. The continuing increase in overweight, obesity and diet-related non-communicable diseases worldwide is a clear indicator of this latter trend (Global Panel on Agriculture and Food Systems for Nutrition, 2016).

Meanwhile, the food economy is becoming more responsive to growing consumer demand for specific food items, which reflects income growth, age structure, levels of urbanization and changing tastes. Increasingly, food suppliers study the evolution of food demand in order to plan food chain investments more effectively, from input supply to consumption (Timmer, 2014). Efforts to improve the efficiency of agricultural value chains, and achieve sustainable food security and nutrition, are constrained by the inequalities facing rural women. Across all developing regions, women play important roles in food production and value addition, and shoulder primary responsibility for the unpaid care of family members. Mothers usually choose what the youngest children eat, and women often have the most influence in determining what the whole family eats.

Women's knowledge, education, social status, health and nutrition, and their control over resources are key factors that affect nutritional outcomes. Many studies show that women's social and economic empowerment – the result of improved education or access to regular income – is one of the most relevant factors contributing to improved children's health and nutrition (Scaling Up Nutrition, 2016; Cunningham *et al.*, 2015). Unfortunately, the persistence of gender-based discrimination means that women do not benefit equally from agrifood value chain development. In many low-income countries, they remain trapped in the low-skilled and low-paid nodes of the food supply chain, often in casual and insecure employment (Kilic, Palacios-Lopez and Goldstein, 2014).

Longer food value chains may have a larger ecological footprint

As the pressure on scarce land and water resources increases, the agrifood sector must find ways of reducing its environmental impact, which includes greenhouse gas emissions, water usage, food loss and waste, and its effects on soil health, ecosystem services and biodiversity. Intensive production and longer food supply chains may be associated with higher GHG emissions from both production inputs (e.g. fertilizers, machinery, pesticides, veterinary products and transport) and activities beyond the farm gate (e.g. transportation, processing and retailing).

Global value chains have substantially increased the use of long-distance transport between primary production, processing and consumption. However, there is mixed evidence of whether long-distance value chains have higher GHG emissions than short chains. The level of overall emissions from a food production process is determined not only by transport but also by production, processing, storage and distribution (Kneafsey *et al.*, 2013).

In the same vein, a comparison of 'local' and 'non-local' food in terms of GHG emissions concluded that the least detrimental effect on the environment depends on the food product, the type of farm operation, transport, season, and the scale of production (Edwards-Jones *et al.*, 2008).

Thus, the adoption of comparatively low-emission technologies in primary production phases could more than compensate for higher emissions from 'long' value chains. However, if technologies that produce high levels of GHG emissions are adopted to produce food that is transported far from its origin, this will result in comparatively higher GHG emissions. For instance, farmers in Kenya supplying leaf cabbage to local supermarkets use almost twice the amount of chemicals per unit of output that farmers normally use (Neven *et al.*, 2009). If supplying supermarkets requires more chemical fertilizer and fossil energy per unit of output, GHG emissions may increase during the transition from 'traditional' to 'modern' value chains. Since the production of fertilizer, herbicide and pesticide, along with emissions from fossil fuels used in the field, represent about 2 percent of total GHG emissions (HLPE, 2012), increases in the use of these inputs is likely to have significant global impacts.

Finally, food safety and quality standards imposed by supermarkets and regulators may lead to the discarding of food that is still safe for human consumption, representing an enormous waste of natural resources. Therefore, the evolution of food systems needs to be assessed not only in terms of economic efficiency and capacity to improve food security, but also in terms of their environmental impacts along the entire food chain.

Could indigenous food systems feed the world? No, but they can help

Sustainability concerns have shaped the emergence in high-income countries and in some areas of Latin America and Asia, of a consumer preference for high-quality local foods linked to traditions and culture. Increasingly, global food movements such as 'Slow Food' are promoting this holistic approach to food (Slow Food, 2016). A related development in the evolution of food systems is the growing potential of indigenous food systems and neglected crops to contribute to the diversification of diets away from the narrow food base of maize, rice, wheat, barley and soybean. The recent appearance in mainstream markets of indigenous foods such as quinoa, amaranth, chia, argan oil and moringa, highlights this potential.

Indigenous food systems have characteristics that make them particularly attractive, including the use of both cultivated crops and gathered wild plants, synergies with the natural environment and biodiversity, close adaptation to local conditions, a high level of diversification, a light carbon footprint, fewer 'negative externalities' and reduced use of external inputs. They are closely tied to culture and social and religious activities.

While several indigenous foods (e.g. olluco, sweet potato, yam, kiwicha and native palms in the Andes and Pacific islands) could contribute significantly to the global food supply, it is unlikely that they will become major food commodities without further research and adaptation.

Indigenous food systems tend to be people-centred and many manage resources in a sustainable way. They also combine the consumption of produce with the purchase and sale of food, avoiding a fully commercial

orientation. Foods with these features have appeared only recently in large distribution chains, through production systems such as organic farming, permaculture and biodynamic agriculture, which reflect to some extent the philosophical approaches of traditional societies (FAO, 2009).

While modernizing food systems rely heavily on a few edible plant species and varieties, indigenous systems make use of several hundred edible and nutritious plants. The traditional knowledge, which underpins indigenous systems, is important for two main reasons. First, indigenous 'superfoods' could address some of the nutritional deficiencies that currently affect more than 2 billion people. Second, the production of local plants that are usually consumed in the wild or with minimal domestication, in some cases, can be scaled up using advanced technologies. This is already done in the bio-cosmetic and pharmaceutical industries, which rely heavily on the indigenous knowledge of plants and the medicinal properties of forest products. Similar alliances, if developed for food production, might expand the present, narrow food base (Indigenous Food System Network, 2016).

Indigenous food systems are influencing mainstream food thinking

It is possible that mixed systems will emerge in the years ahead, with some indigenous food producers making more intensive use of technology. Modern communications (e.g. mobile phones, internet and satellites) and self-certification will facilitate market access and reduce the need for intermediaries, thus allowing producers to capture a bigger share of the final product's added value.

The opportunities for indigenous food producers, processors and suppliers have been amplified by the support of leading international chefs with global followings. Just as former niche markets, such as organic food, zero-kilometre food and family-farmed produce, have expanded exponentially in recent years, so too could the markets for many neglected foods and for the produce of indigenous food systems.

However, indigenous food systems face threats, including the destruction of habitats and the displacement of indigenous peoples from their lands; the loss of languages and culture in indigenous communities; the migration of youth to cities as older generations disappear; the loss of traditional seeds; and the rapid shift in food habits among the young, who are influenced by marketing campaigns for processed foods. Anecdotal evidence indicates that indigenous youth are progressively abandoning their food systems. Knowledge about thousands of edible and medicinal plants, which has been built up over centuries of trial and error, could be lost forever, along with the forests, mangroves, lakes, savannas, pastures and mountain ecosystems that host them.

13 | Food losses and waste

Globally, around one-third of all food produced is lost or wasted along the food chain, from production to consumption (HLPE, 2014). In a world where hundreds of millions of people go hungry, that is a stark indication of the inefficiency of current food systems. Food losses and waste often translate into economic losses for farmers and others stakeholders within the food value chain, and higher prices for consumers, both of which affect food insecurity by making food less accessible for vulnerable groups. Reducing food losses and waste would increase the supply of available food and strengthen global food security.

Food losses and waste also hold back the transition to environmentally sustainable food systems. They represent a considerable waste of land, water, energy and agricultural inputs, and cause the emission of millions of tonnes of greenhouse gases. Future efforts to address climate change will need to find ways to reduce food losses and waste. Because food production is responsible for a large share of GHG emissions, reducing food losses and waste contributes to climate change mitigation. At the same time, because climate change threatens food production in many food insecure areas, reducing food losses and waste can be an important part of climate change adaptation strategies (Bellú, 2016).

Quantifying trends in food loss and waste is not easy

Measuring food losses and waste is difficult, in part because food supply chains are long and involve many actors, including small farmers, transporters, processors, retailers and households. FAO defines food losses and waste as a 'decrease in quantity or quality of food', i.e. a reduction in the availability of food, a decline in its nutritional and/or economic value, and/or a deterioration in food safety. Food waste results from the 'discarding or alternative (non-food) use of safe and nutritious food for human consumption all along food supply chains'.[1]

Although the difference between food loss and food waste is not cut and dry, food loss is seen as accidentally occurring for reasons not under the direct control of the agents concerned, such as inadequate technology, lack of knowledge and skills, poor logistics and malfunctioning markets, while food waste is characterized by an element of intended or unintended behaviour, i.e. the removal of food fit for consumption by choice or negligence.[2]

Although food waste is often associated with final consumption, the deliberate discarding of food may occur at all stages of the supply chain.[3]

[1] For more on FAO's work on food losses and waste, including definitions, see www.fao.org/food-loss-and-food-waste/en and www.fao.org/platform-food-loss-waste/en

[2] These definitions contain a grey area associated with deliberate choices. Undesired reductions of output may occur, in many cases, as a consequence of deliberate choices not to invest to prevent them. For instance, deliberately deciding not to invest in storage facilities because the investment is not considered profitable may lead to reductions of outputs, which are still undesired, although occurring as a consequence of a deliberate choice grounded on economic rationale. As this is an 'indirect', deliberate reduction of output, it could be classified as a food waste. A different situation may occur when an economic agent considers it profitable to invest in preventing food losses but has no possibility to do that (e.g. due to lack of access to credit). In this case, the reduction of output could be considered a loss, at least from the individual agent's perspective.

[3] At least in principle, these new definitions do not limit the occurrence of food waste to the end of the food chain (distribution, sale and final consumption). See for instance: Parfitt, Barthel and Macnaughton, 2010.

The distinction between food loss and food waste is important, because it underscores their different underlying causes. Policies and strategies need to take these into account when seeking solutions to the problem.

The causes of food losses and waste vary greatly by region

Accurate and time-wise estimates of losses and waste in the food system are unavailable. However, evidence to date indicates that, every year, about 670 million tonnes of food is lost or wasted in high-income countries, and 630 million tonnes in low- and middle-income countries – a total of 1.3 billion tonnes, or one-third of the edible part of food originally intended for human consumption.[4] Food losses and waste are caused by different factors at different levels:

- *Micro-level* causes resulting from the actions of agents at the same stage of the food supply chain (e.g. poor harvest scheduling and timing, poor harvest practices, careless handling of produce, lack of appropriate storage space, lack of transportation facilities, consumer behaviour).
- *Meso-level* causes related to a whole food supply chain, i.e. decisions or lack of decisions of agents in that particular chain (e.g. poor coordination, too long chains, failure to meet product standards, pesticide-contaminated processed products).
- *Macro-level* causes arising from the overall socio-economic environment, such as lack of infrastructure, inadequate legislative frameworks and price incentives and subsidies that promote excess production (HLPE, 2014).

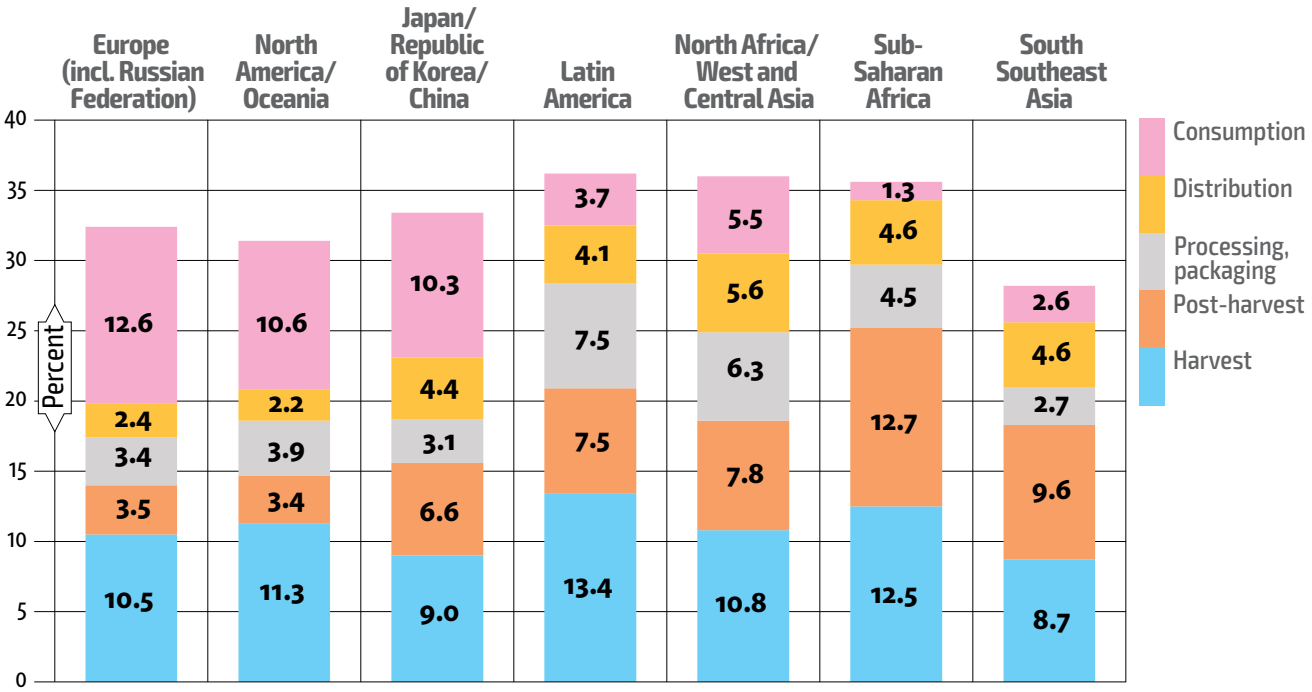
In low-income countries, significant levels of food losses occur upstream, at harvest and during post-harvest handling, owing to poor infrastructure, low levels of technology, a limited knowledge base and lack of investment in production. Food losses also tend to be caused by managerial and technical constraints in harvesting, storage, transportation, processing, packaging and marketing. The greatest losses occur in small- and medium-scale agricultural and fisheries production and processing sectors. Uncertainty about weather and market conditions, and weak institutional frameworks, also contribute to losses. Each year in Africa, around 13 million tonnes of cereals, or more than 15 percent of total cereal production, are lost during post-harvest operations.[5]

In all regions, except South and Southeast Asia, food losses and waste account for more than 30 percent of food originally intended for human consumption. However, the extent of losses and waste along the food supply chain differs across regions (Figure 13.1) (HLPE, 2014). In North America, Europe, Japan and China, around 15 percent of food is lost or wasted in the distribution and consumption stages. This percentage is lower in North Africa and Central Asia (11 percent) and much lower in Latin America, South and Southeast Asia and sub-Saharan Africa (5.9 to 7.8 percent). In contrast, North America, Europe, Japan and China lose or waste only around 15 percent of food in the harvest and post-harvest stages. In sub-Saharan Africa, where food losses and waste are particularly high at 36 percent, some 5.9 percent occurs in the retail and consumption stages, while more than 30 percent occurs in the harvest, post-harvest and processing stages.

[4] Data refers to year 2007. Based on FAO, 2011.

[5] Five-year average for 2008–2012 based on author's calculations (APHLIS, 2016).

Figure 13.1 Distribution of food losses and waste along the supply chain



Note: Initial production is edible part originally intended for human consumption.
Source: HLPE, 2014, based on FAO, 2011.

In the United States of America, food waste at the retail and consumer levels is estimated at more than 60 million tonnes per year. This represents 31 percent of the total available food in the food supply chain and corresponds to around 1 250 calories per capita per day (Buzby, Wells and Hyman, 2014). In the European Union, more than 100 million tonnes of food are wasted each year (European Commission, 2016). With rapid urbanization and growth of supermarket chains in low- and middle-income countries, the level of food waste in their urban centres is increasing.

Greater awareness has spurred calls for action

Mounting evidence of the extent of food losses and waste has led to calls for global coordinated action to address the problem. 'Zero food loss and waste' is one of the pillars of the 'Zero Hunger Challenge', which was launched by the UN Secretary General in 2012. In 2015, world leaders committed themselves to addressing this challenge and set out to halve per capita food waste and to reduce food losses by 2030 within the context of the 2030 Agenda on Sustainable Development and as part of Sustainable Development Goal (SDG) 12, which aims to ensure sustainable consumption and production patterns.

The strong focus on reducing food loss and waste in the SDGs has increased the attention being paid to research, measurement, monitoring and actions in this area. Coordinated efforts to improve reporting are important because studies of global trends in food loss and waste often use different estimation methods.[6]

To overcome these limitations, several development agencies have established the Food Loss and Waste Protocol, a multistakeholder effort to

[6] For instance, FAOSTAT, the FAO global database of food and agriculture, reports waste by commodity, country and year as an item in the 'commodity balance sheets'. Figures in FAOSTAT exclude waste before and during harvest, waste at household level and wastes occurring in processing, as they are embedded in extraction rates. In addition, they are often calculated as a fixed percentage of availability, the latter being defined as production plus imports plus stock withdraw (see FAOSTAT glossary). This makes comparisons of waste data from FAOSTAT not directly comparable with other data provided by global and regional studies. For more information consult the FAOSTAT web site at http://faostat.fao.org (FAO, 2016a).

develop global accounting and reporting standards. The first version of the Food Loss and Waste Standard was released in June 2016.[7] FAO is working on a Global Food Loss Index indicator, which uses the caloric content of food as a common unit of measure for assessing progress in reducing food losses and waste.[8] To address knowledge gaps, raise awareness, and reduce food losses and waste through policies, programmes and projects, global public-private partnerships, such as the Global Initiative on Food Loss and Waste Reduction (the 'Save Food' Initiative), have been launched.[9] The Save Food Initiative is an umbrella programme that hosts various global, regional and international initiatives, projects, campaigns and partnerships.

Food losses and waste are increasingly an environmental issue

The urgent need to address climate change and make food systems more environmentally sustainable has pushed the issue of food losses and waste to the forefront. Food losses and waste have negative environmental impacts. When food is squandered, so too are the water, soil, biodiversity and other natural resources and inputs that were used to produce it and move it through the supply chain. These impacts can be expressed as a 'food loss and waste footprint' on the environment. Studies have estimated that the agrifood sector currently accounts for around 30 percent of the world's total energy consumption, and that the energy embedded in global food losses is 38 percent of the total final energy consumed by the whole food supply chain. This means that more than 10 percent of the world's total energy consumption is for food that is lost and wasted.

Attempts have been made to quantify the global environmental impacts of food losses and waste, especially with regards to greenhouse gas emissions. By one estimate, food losses and waste generate every year more than 3.3 gigatonnes of carbon dioxide equivalent (FAO, 2013), equal to the combined annual carbon dioxide emissions of Japan and the Russian Federation.

Improving the efficiency of food systems, so that less food is lost and wasted, has been identified as an important way of reducing GHG emissions from the food and agriculture sector without compromising food security. The redesign of food supply chains and the introduction of sustainable technologies and improved retail models, which are needed to reduce food losses and waste, may also make food systems more energy-efficient and indirectly reduce emissions. More efficient food systems also recycle resources more effectively and require less transport and storage. All of these benefits lead to savings in natural capital, reduced consumption of resources and lower GHG emissions.

Finding ways of reducing food losses is a delicate balancing act

Approaches to reducing food losses in the food supply chain often involve greater use of energy, especially for the preservation of food products. How this energy is produced and delivered to the different points along the value chain will have an impact on the environment and the local economy. This implies that not all losses should be eliminated, as the economic, social and environmental costs of eliminating them may well exceed the benefits. The challenge, therefore, lies in weighing the economic, social and environ-

[7] The Food Losses and Waste Protocol is coordinated by the World Resources Institute (WRI) and comprises the Consumer Goods Forum (CGF), FAO, the European Union funded project Food Use for Social Innovation by Optimising Waste Prevention Strategies (FUSIONS), United Nations Environment Programme (UNEP), the World Business Council for Sustainable Development (WBCSD), and the UK-based charity WRAP. More information can be found at: www.wri.org/food/protocol (World Resources Institute, 2016). The Food Loss and Waste Standard is available at: http://flwprotocol.org (Food Loss + Waste Protocol, 2016).

[8] The GFLI index covers losses at farm, transport, storage and processing levels. Waste at the household level is excluded. For more information visit the FAO Technical Platform on the Measurement and Reduction of Food Loss and Waste web site at www.fao.org/platform-food-loss-waste (FAO, 2016c).

[9] The Save Food Initiative is a joint programme between FAO and Messe Dusseldorf, a German exhibitions company, involving private and public partners aimed at achieving reductions in food losses and waste. For more information visit: www.fao.org/save-food (FAO, 2016b).

mental costs and benefits of different approaches to reducing food losses, and in determining the approach that best ensures food security, improves environmental sustainability and builds resilience to climate change within a given community.

Reducing food losses in climate-smart ways, i.e. ways that reduce or remove GHG emissions while improving food security, and increasing local capacities to adapt to climate change, is contingent upon the development and uptake of sustainable technologies along the entire value chain, particularly in post-harvest operations and during processing and storage. To have maximum impact, climate-smart, food-saving technologies should also be gender-sensitive and generally socially acceptable. Women often have limited access to technologies and services, which is an important contributor to food losses in the supply chain. At the same time, technology development should safeguard the nutritional value of food products.

Many potential options for climate change mitigation and adaptation technologies capable of reducing food losses are available in low-income countries. However, to date, relatively little attention has been given to exploring the options. Over the past 30 years, 95 percent of research investments are reported to have focused on increasing production, while only 5 percent were directed towards reducing losses, despite the high potential that food loss reduction has for containing the need for future additional food production (Kader, 2005; FAO, 2004; Aulakh and Regmi, 2013).

By reducing food losses, climate-smart technologies also present an important opportunity for countries to tap into climate finance mechanisms, which can support them in reaching their climate change mitigation and adaptation goals.

[10] For a detailed discussion of the economic rationale of food losses and waste, see De Gorter, 2014.

Reducing food waste requires changing people's behaviour

In dealing with the problem of food waste, technological fixes do not offer lasting solutions. Responses must address the attitudes and actions of a range of stakeholders throughout the food supply chain. In high-income countries, food waste is caused mainly by consumer behaviour and economic decisions, and by policies and regulations related to other sectors. For example, agricultural subsidies may encourage the production of surplus food crops. This excess production helps contain prices but also causes less attention to be paid to food waste, both by value chain stakeholders and by consumers. Food waste is most often caused by retailers and consumers over-purchasing and then simply throwing away perfectly edible foodstuffs. In addition, food safety and quality standards may remove from the supply chain food that is still safe to eat. At the consumer level, inadequate planning of purchases and failure to use food before its expiry date also contribute to food waste.

In addressing the behavioural causes of food waste, policy makers must recognize that food waste may be rational from an individual's perspective, resulting from the 'optimizing behaviour' of producers, processors, traders, and consumers.[10] However, there are economic costs and negative externalities that individual economic agents may not consider, owing to imperfect markets and a lack of information.

From the point of view of society as a whole, food waste is considered undesirable because it generates net losses through its environmental impacts and associated socio-economic costs. Policies need to create conditions that enable the behaviour of different individual agents along the food supply chain to achieve a socially optimal level of food losses and waste. These policies include 'getting food prices right' by ensuring that the consumer assumes full responsibility for covering the environmental and social costs of producing – and eventually discarding – food. The recovery and redistribution of safe and nutritious food is another strategy option for reducing food waste.

14 | Governance for food and nutrition security

Efforts to achieve the Millennium Development Goals enhanced awareness of the crucial role of responsible and effective governance in achieving key development objectives. The importance of governance was stressed with the adoption of the 2030 Agenda for Sustainable Development, which constitutes a new charter for international cooperation and governance and which explicitly aims to 'build effective, accountable and inclusive institutions at all levels' through Sustainable Development Goal 16 (UN, 2015b). The radical reformulation of development means and ends, defined by the 2030 Agenda, finds parallels in the less visible, but equally profound, shift that has taken place in thinking about governance among governments, international institutions and the international expert community.

For the 2030 Agenda, all countries are 'developing countries'

Integral to the 2030 Agenda are the Addis Ababa Action Agenda on financing for development (UN, 2015a) and the Paris Agreement on climate change (UNFCCC, 2015), along with other international agreements, such as the outcomes of the Second International Conference on Nutrition (ICN2). It is supplemented by the outcomes of the World Humanitarian Summit.

The 2030 Agenda goes beyond the traditional objective of overcoming the divide between 'developed' and 'developing' countries to propose a new vision: that of addressing inequalities within as well as among nations. Where conventional wisdom once focused on discrete instruments to address rigidly defined sectoral and sub-sectoral objectives, the new agenda draws attention to the links and dependencies among issues and problems. And, where 'development' addressed mainly the needs of low-income countries, sustainable development is presented as a universal challenge – and a collective responsibility – for all countries.[1]

Along with this profound conceptual change, there is a striking sense of urgency and *ambition* in the new sustainable development agenda, in terms of both the ends and the means. The aspirations of the Agenda are transformative. It demands, as the first steps toward eliminating all forms of exclusion and inequality everywhere, an end to poverty, hunger and malnutrition, and universal access to health care, all with strong attention to gender issues; it seeks a global shift to sustainable consumption and production; it contains a legal instrument, the Paris Agreement on

[1] See also Bellù, 2011, p. 39.

Figure 14.1 The Sustainable Development Goals

climate change, which commits all nations to taking steps to prevent global temperature from rising 2°C above pre-industrial levels; and it includes a pervasive and demanding commitment to 'leave no one behind'.

Underpinning the 2030 Agenda are radical new approaches to international cooperation and mutual accountability. A distinguishing characteristic of the agenda is its comprehensive view of the required means of implementation, which dramatically expands traditional financing for development to include new ways of facilitating least developed countries' access to markets, technology, capacity development and policy support. SDG 17, to revitalize the global partnership for sustainable development, specifically addresses the need to strengthen the means of implementation, supported by the concrete policies and actions agreed in the Addis Ababa Action Agenda. Where traditional forms of international cooperation have been based on agreements between states, the 2030 Agenda makes another important departure with its pronounced shift toward enabling collaboration between private sector and other non-state entities.

The new SDG governance framework is shaped by six salient features

First, it implicitly recognizes that no country is today on a sustainable pathway, and that no country can achieve all of the goals on its own. The concept of development embraced by the Agenda does not wholly set aside the North-South divide or the social dimensions of development. However, it brings to the fore a dimension of development that is universal in orientation, by insisting that all countries need to take steps – each within its own capabilities and in line with the ambitions of the new framework – to transition to new development pathways that are more inclusive, equitable, sustainable and climate-responsible.

Second, the global goals and targets are set from the 'bottom-up'. The SDGs were developed through a process initiated and controlled by Member

States and organized according to the multilateral principle of sovereign equality. At the level of targets, each government is free to set its own national targets guided by the global level of ambition but taking into account national circumstances. National ownership of the new agenda by Member States is the intended objective, and ensuring effective inter-governmental accountability for collective results becomes the critical challenge.

Third, the 2030 Agenda was negotiated during a long-term global economic slowdown, with exceptional pressure on most available public financing, and in a mood of general political and economic retrenchment. The new Agenda does not anticipate renewed growth of public expenditure and proposes greater reliance on national resource mobilization as well as enhanced cooperation with private entities to provide the material sinews of development action.

Fourth, at the core of the new agenda is a new, expanded vision of 'policy coherence'. It recognizes development as an inherently complex process, which is possible only when public and private actors recognize the necessity of taking into account the mutual dependencies, constraints and trade-offs of action across sectors. It rejects simple solutions, and promotes lateral, integrative and holistic thinking in the way it defines problems to be solved. This new vision comes at a price: in such a world, policy analysis, governance, and programme delivery are far more complex undertakings than those envisaged under the MDGs.

To master this complexity, the 2030 Agenda demands new, more context-sensitive approaches to policy-making, new hybrid forms of governance in which the roles and responsibilities of public and private entities are often shared, and much greater commitment to cooperation by all development partners. Most importantly, it challenges the UN system and each of its entities to become a coherent, flexible, effective, efficient and user-friendly support to the most ambitious mobilization for global development in history. The UN system entities have largely been left to decide – together – how to translate the Agenda into practical action and what roles they can play in catalysing action by others. Failure to develop greater coherence will have negative consequences for the UN development system and all its entities.

Fifth, the 2030 Agenda represents a different 'grand bargain'. The MDGs were often presented in terms of a political 'grand bargain' between low- and middle-income countries, on one side, and high-income 'donor' countries. This was described in MDG 8 as a 'Partnership for Development' – in essence, a North-South accord between donors and their beneficiaries. In place of that historic partnership, the 2030 Agenda offers expanded cooperation to provide access to finance and investment, markets and technology, policy support and capacity development. But it does so in a new context of partnerships that relies heavily on private, and especially commercial, entities, not official transfers, to provide the 'means of implementation'.

Finally, the 2030 Agenda establishes a different approach and level of commitment to 'mutual accountability'. Control over development finance is a much weaker source of policy bargaining than it was in the past. The demand of many low-income countries for policy space is amply recognized, not only with words but also through the massive expansion of targets and

the freedom allowed to countries to establish their own national targets. In place of the finance-centred mechanism of the MDGs, the Agenda posits a multilateral mechanism for mutual accountability: a new and expansive global framework for reporting on 231 unique indicators; monitoring commitments, policies and experiences, with analysis and evaluation by specialized intergovernmental bodies; and local, national, regional and global follow-up and review by political decision-makers at all levels.

For FAO, the main challenge posed by the 2030 Agenda is that of thinking beyond the resources it uniquely controls and asking hard questions about how it can more effectively catalyse action by others. The Organization is also called upon to help governments and regional and global institutions to cope with the complexity of the new agenda by breaking down the complicated tasks they have set for themselves into discrete, solvable problems. As a first step, FAO must present a simplified, but clear and coherent narrative of its own expected contribution to its Member Countries' achievement of the new goals. The narrative should signal to partners and stakeholders what can be expected from FAO and in what areas of work.

The Organization may need to draw more deeply on its own experiences and those of others to ask: how it can become a trusted and effective facilitator and enabler of the ambitious and accountable partnerships that the Agenda for Sustainable Development demands. FAO is asked consider again how best to balance its global role in providing data, norms and standards with its crucial mandate to foster transformational change. Most challenging of all, the Agenda compels FAO to evaluate its contribution to, and collaboration with, the many other actors that constitute the United Nations development system, in particular the Rome-based agencies, IFAD and WFP.

'Good governance' has given way to more pragmatic, problem-driven decision-making

For more than two decades, beginning in the early 1990s, expert thinking in the international development community was predominantly focused on the concept — which then became a political project — of promoting 'good governance'.[2] At the peak of its popularity, from the early 1990s to the late 2000s, the good governance agenda generally prioritized commitments to improving transparency, broadening participation and ensuring social inclusion in deliberative processes, eliminating corruption and promoting institutional reform. Backed by good governance programme lending, enormous investments were made in fostering new standards of financial management and public administration. This work was matched by a comprehensive programme of the World Bank to develop indicators and implement monitoring systems to track governments' progress toward meeting these normative, and highly formalized, criteria of good governance.

The expectation was that, over time, a strong positive correlation would be established between progress toward 'good governance', as defined by the good governance indicators, and high or improved economic performance. By the mid-2000s, however, it was becoming clear that this expectation would not be met. A key limitation of the good governance agenda was that it was too formal and procedurally oriented to address the complex

[2] A significant counterpoint to the 'good governance' concept was developed around the work of the American political economist, Elinor Ostrom.

policy bottlenecks and political conflicts that impede effective governance. At the same time, governments became increasingly less willing to invest in programmes that offered few tangible benefits and were seen as a diversion from more important development objectives.

Finally, over the past decade, the preponderance of expert opinion has moved away from the 'good governance' project in favour of a more modest and pragmatic agenda, defined by a commitment to iterative, bottom-up, problem-solving and experimentalist approaches to improved or more effective governance.[3] FAO has made important contributions to this new thinking by fostering innovation in its own institutional arrangements, particularly the reform of the Committee on World Food Security (CFS), which has been recognized by the UN as the premier international and intergovernmental platform for inclusive, multistakeholder engagement on food security and nutrition.[4] It has also articulated and demonstrated the value of important conceptual approaches, such as the governance of tenure of land, fisheries, and forests, and the territorial approach to development, which supports multisectoral governance in local, municipal and regional contexts.

Today, these new governance approaches are frequently supplemented by political economy analysis, which seeks to identify and evaluate the roles, interests and likely responses of key stakeholders and institutions to policy change. The goals of this analysis are threefold. First, it guides the design and evaluation of technical solutions, which have to be informed by a realistic appraisal of the political, economic and social context for which they are being designed. Second, it helps to identify both key stakeholders, including the poor and politically voiceless, who must be consulted and engaged, as well as the vital substantive issues and interests that need to be addressed in the decision-making process to ensure outcomes that are both workable and legitimate. Third, it provides political and social parameters for institutional adaptation and development.

Together, the specific challenges facing food security and nutrition identified, the 2030 Agenda for Sustainable Development, and new conceptual thinking about governance in the international development community point to a new and comprehensive agenda for improved governance of food and agriculture at all levels.

[3] See, for example, Levy, 2014; Andrews, 2013; Booth, 2012; Grindle, 2002; Jomo and Chowdhury, eds, 2012; De Burca, Keohane and Sabel, 2014.

[4] For a discussion of the CFS's positioning in the broader context of global governance, see Vos, 2015.

15 | Development finance

Investment in food and agriculture is one of the most effective means of stimulating economic growth and reducing poverty, especially in countries at a low level of economic development. It is also essential for ending hunger and malnutrition in all of their dimensions – by increasing food production to meet growing demand, by improving the access of vulnerable people to food, and by stabilizing markets so that prices are affordable for consumers and remunerative for producers. Food and agricultural investments are also necessary to improve the resilience of rural incomes and livelihoods by addressing climate change, conserving natural resources and facilitating the transition to sustainable agriculture.

Implementing the 2030 Agenda for Sustainable Development requires a comprehensive investment approach, one that mobilizes public finance, sets appropriate public policies and regulatory frameworks, unlocks the transformative potential of people and the private sector, and creates incentives for changes in consumption, production and investment patterns (UN, 2015c). While Official Development Assistance will continue to be a critical source of investment in achieving the Sustainable Development Goals in low-income countries, the past decade has seen important changes in the development finance landscape. More funding options have become available from a variety of sources, such as new development banks, the private sector and foundations, non-governmental organizations and specialized funds. However, there is growing awareness that more funds are needed to implement the agenda.

The landscape for development finance is changing

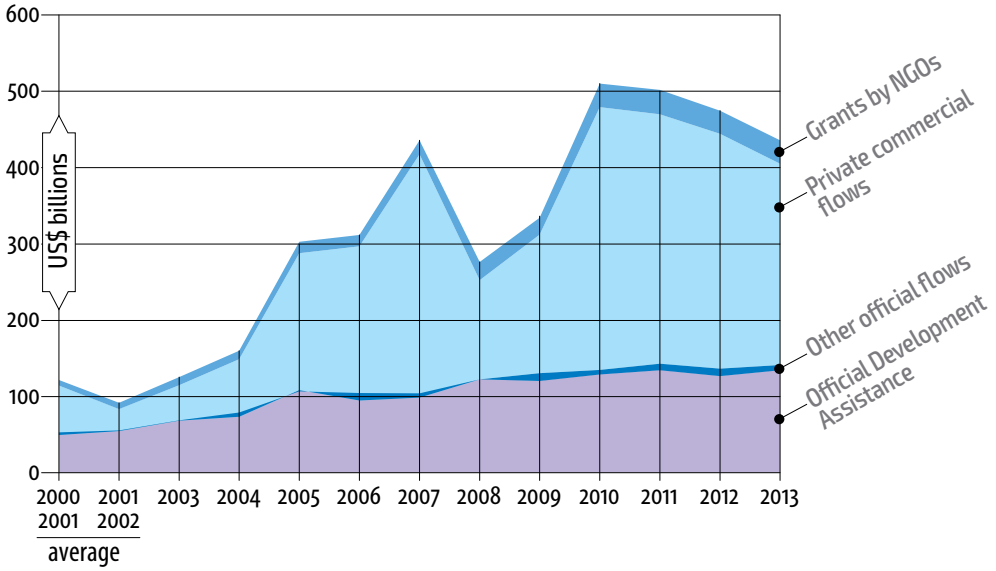
The past decade has seen significant increases in the level of financial flows to low-income countries from members of the Development Assistance Committee of the Organisation for Economic Co-operation and Development (OECD-DAC) (Figure 15.1). This reflects the growing importance of international private finance, particularly increased flows to middle-income countries in the form of foreign direct investment (FDI), bonds and syndicated bank lending with at least five years of maturity, and private philanthropy from foundations and NGOs.

In addition, there are two important sources of external finance to low-income countries, which have increased significantly over the past two decades, but are not featured in Figure 15.1 – remittances[1] and official financing from the emerging donors in the South, such as Brazil, China and India, for which insufficient consistent data are available. ODA levels reached US$132 billion in 2015, but their pattern has been uneven.

[1] Currently estimated at more than US$500 billion a year, or four times the level of ODA.

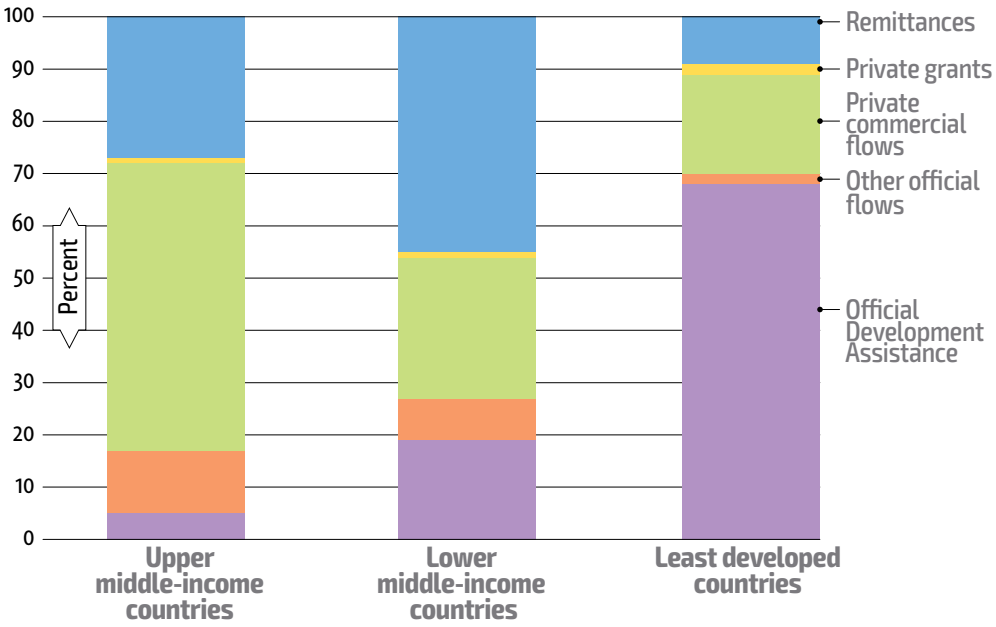
For example, ODA flows to Africa have declined in real terms over the last several years. If all OECD-DAC countries were to meet their long-standing commitment to set aside 0.7 percent of their gross national income, current ODA levels would more than double (UN, 2015d).

Figure 15.1 Financial flows to low-income countries, 2000–2013



Note: Refers to net financial flows originating from OECD-DAC member countries. Private commercial flows include direct foreign investment, export credits, bonds and other commercial portfolio investments in developing countries. Grants by NGOs include contributions from private foundations.
Source: OECD, 2015.

Figure 15.2 Composition of financial flows to low-income countries, 2012



Note: See Figure 15.1 for definition of types of flows.
Source: OECD, 2015.

A new architecture of development finance has emerged across countries at different stages of development, presenting specific financing challenges and opportunities (Figure 15.2). ODA remains a significant source of finance for low-income countries, fragile states and states in in conflict. While the share of ODA in overall external financing for upper middle-income countries is relatively small – they now rely primarily on private flows in the form of FDI and bonds – they nonetheless receive 40 percent of ODA grants.

Beyond the financial flows depicted in Figure 15.1, domestic resource mobilization has become increasingly a key source for funding national development plans. Relatively strong growth in many low-income countries lifted domestic resource mobilization through taxes to US$7.7 trillion in 2012 (IMF and World Bank, 2015). That is, each year low-income country treasuries collect some US$6 trillion more than they did in 2000, which helps to lower aid dependency and raise the creditworthiness of many countries. However, increasing revenue mobilization remains a challenge for many governments, particularly in low-income countries. Moreover, some of the recent revenue gains in low-income countries reflect increased global demand for natural resources, and remain as volatile as commodity prices.

In a post-2015 world, traditional ODA and domestic resource mobilization are likely to remain important to finance development efforts of low-income countries. However, they may not be enough to finance efforts that meet the global ambitions of the SDGs.

Adequate financing is the lynchpin for the success of the 2030 Agenda

Achieving the SDGs requires the implementation of a range of measures through country-led and country-specific strategies and processes (UN, 2015b).[2] The foundation and framework for their implementation is provided by the Addis Ababa Action Agenda (UN, 2015a), which was endorsed by 193 countries at the Third International Conference on Financing for Development in July 2015. Considered a turning point in international cooperation, the Addis Agenda seeks to tackle a range of economic, social and environmental challenges, and identifies priority areas for the mobilization of public and private resources in support of national development plans.[3]

Commitments include taking action to fight hunger and malnutrition, and supporting sustainable agriculture, including forestry, fisheries and pastoralism. The agenda pledges to strengthen efforts to enhance food security and nutrition, with a focus on smallholder and female farmers, as well as agricultural cooperatives and farmers' networks. Recognizing the enormous financing needs in these areas, governments have committed themselves to increasing public investment, which plays a strategic role in financing research, infrastructure and pro-poor initiatives, while also encouraging increased private investment (UN, 2015a). In related commitments, the Addis Agenda calls for the adoption of measures to ensure the proper functioning of food commodity markets and their derivatives, and to facilitate timely, accurate and transparent access to market information in order to limit excessive price volatility. It also calls on World Trade Organization members to correct and prevent trade restrictions and distortions in world agricultural markets.

[2] FAO, IFAD and WFP estimate a requirement of about USD 145 billion in additional investment to achieve zero hunger by 2030.

[3] Critical areas for investment to support sustainable development include technology and innovation, trade and financial sustainability, data collection and analysis, debt and debt sustainability, and some systemic issues, such as global financial governance and the roles and responsibilities of financial institutions in sustainable development.

The 2030 Agenda and the Addis Ababa Action Agenda recognize that the financing needed to achieve the SDGs will very likely be vast. However, no precise estimates of the financing requirements are available. Determining them is extremely difficult, not only because the implementation plans for the 2030 Agenda are yet to unfold, but also because the need for resources will be a moving target, dependent on the speed of implementation and how global economic conditions evolve. Furthermore, the impacts of climate change cannot be determined with certainty, although projections suggest that they will become increasingly adverse over time. Delays in the implementation of the 2030 Agenda would increase the costs of action, assuming it is not yet too late.

Nonetheless, a number of tentative estimates of the possible costs have been put on the table recently. All point in the direction of additional investment requirements of more than US$1 trillion per year. The Global Commission on the Economy and Climate Change estimates that, over the next 15 years, the global economy, including high-income countries, will require an estimated US$89 trillion for climate change action alone (The Global Commission on the Economy and Climate, 2014). These resources would be needed for infrastructure investments across cities, energy and land-use systems worldwide, along with a US$4.1 trillion in incremental investment in the low-carbon transition, which is needed to keep global warming within the internationally agreed limit of a 2°C increase.

In a report on transitioning to green economies, the United Nations estimated that additional financing needs for climate change mitigation and adaptation in low-income countries would average between US$140 billion and US$175 billion a year in 2010–2030. Additional upfront investments of between US$265 billion and US$565 billion would be needed in the first years of that period to jump-start emission reductions; a further US$30 billion to US$100 billion a year would be needed for adaptation (UN, 2011).

The same UN report estimates the average annual cost of incremental investments in sustainable development to be made in low-income countries – including investments to provide clean energy for all, end hunger, make food systems sustainable and improve forest resource management – at about US$1.1 trillion in the coming decades. These findings are presented in Table 15.1, with the figure for the cost of ending hunger as estimated in FAO, IFAD and WFP (2015). Including that estimate, incremental investment requirements for low-income countries approach US$1.5 trillion a year, or roughly 2 percent of global GDP. That would not seem to be an insurmountable cost.

Table 15.1 Tentative estimates of annual incremental investments needed in energy, agriculture and food security for sustainable development (US$ billions)

	Aims and assumptions	Incremental investment needs 2000-2050	Of which, in developing countries
Climate change mitigation: ***Energy supply***	Stabilize greenhouse gas concentrations to limit warming to <2°C (with at least 50 per cent probability)	1 000	600
Climate change mitigation: ***Energy end-use efficiency***	Significant end-use efficiency increase and greenhouse gas stabilization to < 2°C	800	480
Climate change adaptation ***(mostly in agriculture)***	Minimum investments in securing livelihoods, assuming successful mitigation	105	105
Agriculture and food security	Increasing agricultural yields to ensure global food security without further expanding agricultural land	265	265
Total		**2 172**	**1 452**

Note: In constant 2010 US$.
Source: Adapted from UN, 2012 (Table VI.3).
Data for agriculture and food security are from FAO, IFAD and WFP, 2015.

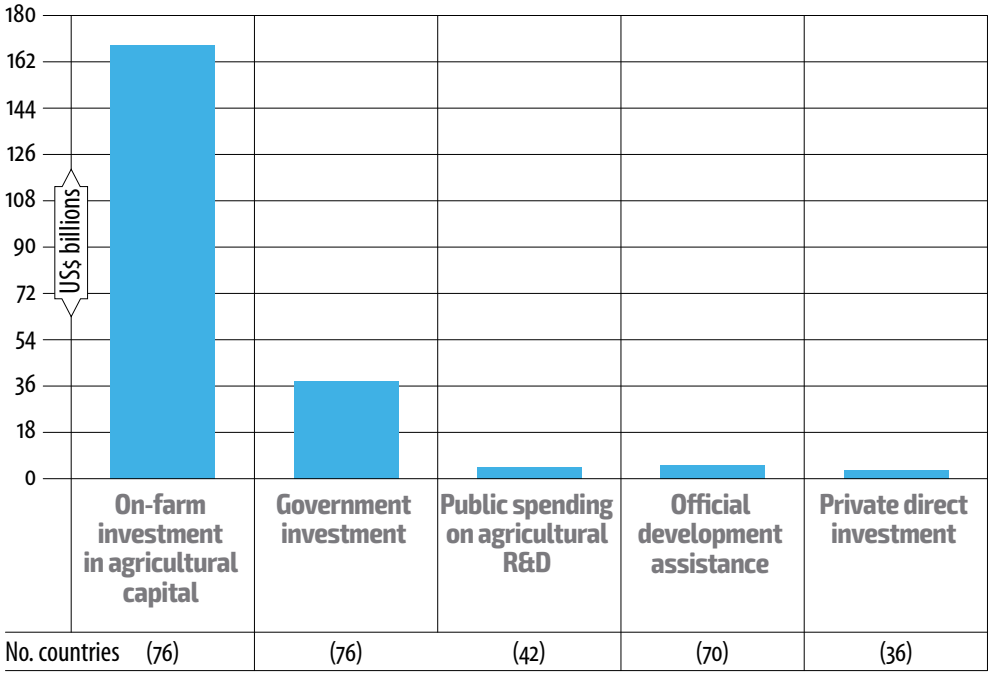
Yet, clearly, these additional investment requirements for low-income countries are well beyond what could be covered by current flows of international development finance, and even more so if only official sources of development finance are considered (Figure 15.1). However, it would not be realistic, or even desirable, to expect all investment needs to be financed through public or external financing mechanisms. More likely, they will need to come from a mix of domestic and external funding and of public and private resources, with public funding and policies acting as a catalyst rather carrying the full investment costs.

The public sector is not a major investor, but its role can be catalytic

Most investments in agriculture tend to be made by private sector agents, especially by the farmers themselves (Figure 15.3). Public investments in agriculture, related infrastructure, and research and development only represent a fraction of total investment in the sector in low-income countries. Foreign direct investment and ODA fund an even smaller fraction.

More than 90 percent of the estimated 570 million farms worldwide are family farms (FAO, 2014). In low-income countries, the vast majority of these farms are less than 5 ha in size. Many smallholders tend to face major barriers accessing the finance needed for investment in improving productivity and adopting sustainable farming practices. They usually have limited financial literacy, collateral and credit history, and few other sources of income (FAO, 2016).

Figure 15.3 Investment in agriculture in low- and middle-income countries, by source, 2005–7 (annual average)



Note: The number of countries covered is shown in parentheses.
Source: FAO, 2012, p. 14, Fig. 5.

Governments can support and play a catalytic role in stimulating pro-poor investments, by securing producers' property and tenure rights, and developing rural infrastructure and public services. Public investment in public goods and services – such as institution building, agricultural extension, productivity-enhancing research, rural transport, health, education and social protection – will be fundamental to creating an environment favourable to pro-poor investment. A positive recent trend is the emergence of partnerships between the public sector, private sector and communities, which promote agriculture and rural development, poverty reduction, food security and improved nutrition.

Also needed are incentives to private banking institutions (including cooperatives) to increase their rural coverage. The creation of employment opportunities in infrastructure development and the public procurement of agricultural products generated by smallholders can also help to stabilize incomes and provide opportunities for low-income rural people to acquire productive assets and inputs, such as land, equipment, fertilizers and seeds.

Agricultural investments generally are considered high-risk given the susceptibility of production to weather and other climatic hazards. This applies particularly to low-income countries, where infrastructure, processing capacity, and cold storage and transportation may be poorly developed. This limits farmers' options to reduce the impacts of seasonality and uncertain weather conditions on incomes and local price stability. Improving infrastructure, building resilience, and strengthening risk-coping mechanisms (e.g. through social protection and agricultural insurance) will be essential to help farmers and agricultural investors hedge against the risks inherent in agricultural production.

More in general, private investments in agriculture will be influenced through broader agricultural and food price policies. Governments around the world provide incentives to farmers and agribusinesses in order to increase agricultural production, influence input costs, supplement farm incomes and achieve other social, economic and environmental objectives, such as landscape preservation, water conservation, poverty reduction, and climate change mitigation and adaptation. Much of the existing production support, worldwide, involves subsidies on inputs, such as fertilizer and energy, particularly fossil fuels, or direct payments to farmers. The OECD countries spent US$211 billion in agricultural production support in 2015, while in the non-OECD countries for which data are available, this support reached US$352 billion in the same year (OECD, IEA, NEA and ITF, 2015).

From the perspective of sustainable development, such support measures may have unintended impacts on the environment. For example, input subsidies may induce inefficient use of synthetic fertilizers and pesticides and increase the emission intensity of production. Almost half of all agricultural subsidies provided by governments of OECD countries in 2010–2012 were classed as 'potentially most harmful to the environment' because they induced greater demand for chemical fertilizers and fossil fuels, which lead to more GHG emissions (OECD, IEA, NEA and ITF, 2015). Such policies influence the magnitude and the nature of investments in agricultural sectors and food systems. Making support conditional upon the adoption of practices that lower emissions and conserve natural resources would be one way of aligning agricultural development and climate goals. Policies in areas such as nutrition, food consumption, food price support, natural resources management, infrastructure development and energy, may similarly need to be reset (FAO, 2016).

New sources of investment financing are emerging

In short, governments' catalytic role in mobilizing private investment in the sustainable development of agriculture and food systems depends not only on public investments in infrastructure and R&D, but just as much on the policies and regulatory frameworks that influence the incentives and support measures that help strengthen farmers' resilience and risk-coping capacities. Much of the public resources needed for such support structures will come from domestic sources, although low-income countries may be unable to make sufficient headway without external support.

As ODA flows have declined in importance, non-traditional sources that have emerged present an opportunity to fill financing gaps. Recent years have seen the appearance of new funding mechanisms, such as the Green Climate Fund, established in 2010 under the United Nations Framework Convention on Climate Change to support policies and investments in low and middle-income countries. Climate finance could act as a catalyst to leverage larger flows of public and private funding for sustainable agriculture, provided policies and institutional frameworks that promote transformative change are in place. Climate finance could also help address the funding gap by demonstrating the viability of climate-smart agricultural investments (FAO, 2016).

Other emerging investment sources include development banks largely financed by middle-income countries themselves, such as the Asian Infrastructure Development Bank, under the leadership of China, and the New Development Bank operated by Brazil, Russia, India, China and South Africa (BRICS), which aims at mobilizing resources for infrastructure and sustainable development projects in BRICS and other emerging economies (BRICS, 2015).

Since achieving sustainable development goals depends on the availability of long-term financing, there is increasing recognition of the need for improvements in the quality of investment preparation and implementation, as well as the adoption of policies and instruments that lower risk and strengthen the confidence of investors in the long-term. Financing a transformative development agenda will also require that resources are used more effectively and strategically to catalyse additional financing.

The need for responsible investments in food and agriculture, which contribute to food security and nutrition, especially for the most vulnerable, and the progressive realization of the right to adequate food, has been widely recognized. In 2014, the Committee on World Food Security endorsed 10 Principles for Responsible Investment in Agriculture and Food Systems (CFS, 2015). This marked the first time a broad range of stakeholders agreed on a set of principles that apply to all types and sizes of agricultural investment and to all stages of the value chain.[4] As a soft law instrument, the non-binding principles are globally applicable and include actions to address a range of environmental, social and economic issues.

[4] Stakeholder groups included governments, United Nations agencies, private sector associations and foundations, civil society and non-governmental organizations, international agricultural research institutions and international and regional financial institutions.

Global challenges facing food and agriculture

Rapid changes in food systems call for effective national and international governance

Several key conclusions can be drawn from the preceding review and analysis of the global trends that are influencing food security, poverty and hunger, and the sustainability of agriculture and food systems.

First, overall demand for food will continue to increase, and will do so in the context of increasing scarcity of natural resources and important changes in the structural composition of the demand for food and agricultural products. Climate change and increased competition for natural resources will continue to contribute to natural resource degradation and scarcity, with negative impacts on people's livelihoods and food security. Problems of extreme poverty, hunger, food insecurity and undernourishment will persist, along with increases in overweight, obesity and diet-related chronic diseases.

Natural disasters are increasing in number and intensity and, along with climate change-related extreme weather events, are expected to deepen the global need for humanitarian assistance and resilience building for farmers and rural households. At the same time, transboundary plant pests and diseases and other emerging threats continue to provoke crises in agricultural and food systems and impact productivity and human health. Conflicts are continuing and could intensify in many parts of the world, with widespread economic and social consequences, beyond the afflicted countries.

Dynamic rural transformation is happening in most low-income countries and is expected to continue. This will have impacts on agricultural production systems, employment, nutrition and migration and will present society with the challenge of finding ways to include everyone in the development process.

Rapid changes and transitions in food systems increasingly call for effective national and international governance systems, and evidence-based and well targeted policy responses. More investment in agriculture and agrifood systems, including increased spending on research and development, is needed to enhance agricultural productivity and promote innovation for sustainable agriculture, rural prosperity and food security.

Based on the conclusions of the analysis of global and regional trends, this chapter outlines a set of 10 Challenges that are the most pertinent to FAO's mission to eradicate hunger and malnutrition, achieve food security for all, improve rural livelihoods, and make agriculture, fisheries and forestry and their natural resource base more resilient, productive and sustainable. The overarching challenge facing food and agriculture will be how to address them as a whole.

Challenge 1
Sustainably improving agricultural productivity to meet increasing demand

Demand for food and other agricultural products is projected to increase by 50 percent between 2012 and 2050. Demand will undergo structural changes, owing to factors such as population growth, urbanization, and per capita increases in income (Trends 1, 2 and 5), while the natural resource base upon which agriculture depends will become increasingly stressed (Trend 3). Producing more with less, while preserving and enhancing the livelihoods of small-scale and family farmers, is a key challenge for the future.

Substantial improvements in resource-use efficiency and gains in resource conservation will need to be achieved globally to meet growing and changing food demand, and halt and reverse environmental degradation. Despite some technological progress, the spectacular growth in yields recorded in previous decades has slowed significantly (Trend 3). The negative side effects of intensive use of chemical inputs in crop production have become increasingly visible and pose serious sustainability concerns.

Investments in agriculture, fishery and forestry, and spending on research and development need to be stepped up, particularly in and for low-income countries. This is required to promote the adoption of sustainable production systems and practices, including integrated crop-livestock and aquaculture-crop systems, conservation agriculture, agroforestry, nutrition-sensitive agriculture, sustainable forest management and sustainable fisheries management. These, and other, forms of climate-smart agriculture will help farms, ecosystems and communities to adapt to, mitigate and build resilience to climate change, and address country-specific needs and gender-specific contexts. In addition, because prevailing price incentives and supports often run counter to sustainable agriculture, a realignment of implicit and explicit agricultural subsidies is also needed (Trend 15).

Challenge 2
Ensuring a sustainable natural resource base

Projections for 2050 suggest growing pressures on agricultural land, water, forests, capture fisheries, and biodiversity (Trend 3). Between now and 2050, the additional land needed for agricultural production is estimated at just under 100 million ha. It is expected that demand for agricultural land will decrease in high-income countries, but increase in low-income countries. The resulting modest increase might suggest that land availability is not a constraint. In fact, increases in the agricultural area is constrained by the fact that available land is not

readily accessible, due to the lack of infrastructure, physical remoteness and disconnection from markets, or is vulnerable to disease outbreaks. Furthermore, available land is concentrated in only a few countries. That is why increases in agricultural production to meet rising food demand will have to come mainly from improvements in productivity and resource-use efficiency.

Water scarcity will also become a growing constraint, particularly in areas that use a high proportion of their water resources and where production systems will be exposed to high environmental and social stress. As well as limiting the potential for expanding irrigated areas, water scarcity has implications for the ability of women to access productive resources (Trend 3). The rate of expansion of land under irrigation is already slowing substantially. Future water stress will be driven not only by shifts in demand, but also by variations in the availability of water resources, resulting from changes in precipitation and temperature driven by climate change (Trend 4).

Challenge 3

Addressing climate change and intensification of natural hazards

Climate change and natural and human-induced disasters pose multiple concerns: damage and losses to production; the degradation of land, forests, water, fish stocks and other natural resources; declining rates in productivity growth; and added pressures on already fragile agricultural livelihoods and ecosystems (Trend 4). Maintaining the capacity of the planet's natural resource base to feed the growing world population, while reducing agriculture's environmental and climate footprint is key to ensuring the welfare of current and future generations.

Food security and human livelihoods will be increasingly jeopardized beyond 2030 owing to climate change impacts. Climate change affects food availability and has adverse impacts on crop yields, fish stocks and animal health. It limits access to food through its negative impacts on rural incomes and livelihoods. Climate change is also seen as a significant 'hunger-risk multiplier'. Some forecasts anticipate that by 2050, as a consequence of climate change, an additional 120 million people will be at risk of undernourishment, of which 24 million will be children; almost half of the increase would be concentrated in sub-Saharan Africa (Trends 4 and 9).

Until 2030, the adverse impacts of climate change will only slightly outweigh positive ones (Trend 4). The benefits derived from increased plant growth under warmer temperatures will mainly occur in temperate zones in higher latitudes, while adverse impacts will be concentrated in tropical zones at lower latitudes. Beyond 2030, adverse impacts will intensify with significant losses of yields in most parts of the world no longer being compensated by positive yield changes in other areas. Extreme events, such as droughts and floods, will intensify and become more frequent with climate change (Trends 4 and 7).

Climate change may also affect nutritional outcomes through its impacts on micronutrient content of certain foods and food safety. In addition, high temperatures and extreme weather events create a more favourable environment for food-borne pathogens that reduce the body's ability to absorb nutrients.

Challenge 4
Eradicating extreme poverty and reducing inequality

Despite global economic growth and a reduction in poverty over the last 30 years, about 2.1 billion people are still living in poverty, with 700 million in extreme poverty (Trends 8 and 11). High and rising inequality is hindering progress towards the eradication of poverty. Even in countries where poverty has been reduced, pervasive inequalities remain between rural and urban areas, between regions, between ethnic groups, and between men and women.

Most of the world's poor and hungry are rural people who earn meagre livings from agriculture, fisheries and forestry. Poor people's reliance on agriculture for their livelihoods, and the high share of their expenditure on food in their household budgets, make agriculture the key to poverty and hunger alleviation. Where economic growth has been slow, the structural transformation of agriculture has stalled, leaving many in poverty.

Agriculture plays an important role in pro-poor growth. Reducing rural poverty requires measures to increase productivity and profitability, link farmers to markets, and provide efficient extension and agricultural advisory services. However, pro-poor growth also depends on factors beyond agriculture. It requires access to good quality education, economic diversification to rural non-farm income generating activities, support for job creation and adequate social protection mechanisms.

Women everywhere tend to face higher barriers than men to productive resources, economic opportunities and decision-making (Trend 11). For farming women, the lack of access to agricultural inputs, services, credit and markets constrain agricultural productivity growth and agricultural production, making the arduous pathway out of poverty especially difficult. In sub-Saharan Africa, the productivity levels of female workers in agriculture are between 20 and 30 percent lower than those of male workers, purely because of the gender gap in access to resources.

Significant additional investments are needed to defeat extreme poverty and hunger (Trends 4 and 15). However, owing to the low current levels of capital formation and the limited 'fiscal space' in low-income countries, there will be a need for external support to investment programmes through international financial cooperation.

Challenge 5
Ending hunger and all forms of malnutrition

Future increases in world population will be concentrated disproportionally in countries with high levels of food insecurity. While average per capita income growth is expected to result in positive nutritional outcomes, addressing the triple burden of malnutrition – undernourishment, micronutrient deficiency and overweight – will remain a challenge for those countries in the decades ahead (Trend 9).

Population growth in low-income countries is expected to stimulate large increases in demand for staple crops, such as roots, tubers and plantains (Trends 1 and 9). At the same time, income growth and urbanization will drive changes in dietary patterns, with substantial increases in demand for cereals, milk and meat products. The shift to higher consumption of animal products and foods rich in fat and sugars, combined with urban sedentary lifestyles, will increase the risks of overweight and obesity.

Improving the access of vulnerable populations to food and ensuring urban food security, especially in low- and middle-income countries in Asia, Africa, Latin America and the Caribbean, will be key to eradicating hunger over the next 15 years. Agriculture and food systems will need to meet the food and nutritional demands of people with rising incomes and changing diets, as well as the demands of a growing number of poor and hungry. While much attention has been given to increasing farm production to meet this demand, equally critical are supply chains that connect farmers to urban markets, along with measures such as pricing policies and social protection, which ensure access for consumers to nutritious and safe food at affordable prices.

The shift in dietary patterns will have a larger environmental footprint, in terms of greenhouse gas emissions and the use of natural resources (Trends 4 and 9). The shift to diets high in milk and meat, particularly from ruminants, is associated with increasing emissions of methane from enteric fermentation, carbon dioxide from deforestation for pasture, and nitrous oxide from feed production. Higher consumption of processed foods requires additional use of water and energy, which has negative environmental impacts, if these resources are not sustainably managed.

Although more research is needed, evidence suggests that dietary patterns that have low environmental impacts can also be consistent with good health (Trend 9). For instance, national dietary guidelines that recommend lower red meat consumption, particularly among high-consuming groups, could help limit GHG emissions.

Challenge 6

Making food systems more efficient, inclusive and resilient

Food systems are characterized by the coexistence of modern and traditional supply channels. However, these systems are changing, as there is a growing reliance in many regions on global supply chains and large-scale distribution systems, such as supermarkets (Trend 12). Capital-intensive, vertically integrated supply chains both respond to the evolving demands for food and dietary preferences and shape the trajectory of their evolution. More efficient food systems also create new challenges and concerns: the high-calorie, but low-nutrient, content of many food items; the reduced access of small-scale producers and family farmers to viable markets; the high levels of food loss and waste; food safety problems; plant disease and animal health issues; and the higher energy intensity and heavier ecological footprint associated with the lengthening of food chains. The implications of these challenges for future food security and nutrition will need to be viewed from the perspective of food systems at large, including the impacts on traditional food chains and the producers and consumers who rely on them.

Strengthened linkages between farms, markets and consumers can be an important source of income growth and job creation in both rural and urban areas (Trends 10 and 12). Formal, structured supply chains increase the efficiency of product flows – from inputs to farmers, and food products to consumers – but have also been found to pose challenges to food security. For example, distribution systems may be concentrated in more affluent urban areas. In addition, the requirements of large supermarkets, for uniformity, consistency, regular supply and large volume, may be difficult for small producers to meet. The impacts of structured supply chains are raising concerns about efficiency and equity. Local food systems remain important, despite the 'supermarket revolution' and the associated rise of modern global food supply chains. Up to 90 percent of food consumption in rural areas of low-income countries comes from domestic sources.

Food losses in low-income countries, occur throughout food value chains, owing to managerial and technical limitations in harvesting, storage, transportation, processing, packaging and marketing (Trend 13). Food waste in middle and high-income countries is caused mainly by consumer behaviour and by policies and regulations that address other sectoral priorities. For example, subsidies may encourage surplus food crop production, which reduces both prices and the attention that is paid to food losses and waste. Some food safety and quality standards may remove from the supply chain food that is still safe for human consumption. At the consumer level, inadequate planning of purchases and failure to use food before its expiry date also lead to waste.

The challenge for many low- and middle-income countries will be to find dynamic pathways that connect local food systems to growing urban markets and to seize market opportunities (Trend 12). Cities account for the lion's share of demand for high-value foods, such as fruits, vegetables

and dairy products. These are markets in which small-scale and family farmers can have an advantage because such products are labour-intensive. Food systems that link farmers to cities can have an enormous impact on rural poverty alleviation and agricultural development. Options include connecting small-scale producers and supermarket supply chains through contractual arrangements with mutually beneficial terms, and giving new impetus to the development of local food systems.

Challenge 7

Improving income earning opportunities in rural areas and addressing the root causes of migration

Pervasive and persistent inequalities are leaving too many rural people mired in hunger and rural poverty (Trend 8). Young people in rural areas of low-income countries often shy away from working in low-productivity agriculture (Trend 10). In the absence of decent work opportunities and access to social services and protection, they join the flow of internal and international migrants (Trends 8, 10, and 11). In many regions, women and older people are left to take care of the farm, but face major constraints in accessing resources to improve their productivity. Addressing those inequalities, through more inclusive rural transformations and the reconfiguration of rural-urban linkages, is a major challenge for the coming decades.

Arguably the single biggest global development challenge in the decades to come will be the need to integrate hundreds of millions of young people into the labour market. The number of people aged between 15 and 24 will rise from about 1 billion in 2015 to 1.2 billion by 2050. Most of these young people will live in sub-Saharan Africa and South Asia. High levels of youth unemployment and underemployment in rural areas prevent households from their diversifying livelihoods and escaping poverty for good. Building human capital through the provision of quality basic social services, particularly education and health, are fundamental building blocks for poverty reduction. However, in many low- and middle-income countries, population growth is outpacing new job growth, and rapid urbanization has not been accompanied by commensurate growth in non-agricultural work. Consequently, agriculture and agriculture-related services will need to continue to absorb a large share of new workers.

Migration is part of economic development and the structural transformation of agriculture (Trends 10 and 11). In the decades ahead, distress migration, both within and across countries, will be accelerated by population growth, globalization, climate change and political conflict. Managing migration flows is another major new challenge that must be met by addressing its root causes and increasing access to social protection and employment opportunities in both origin and destination countries.

Challenge 8
Building resilience to protracted crises, disasters and conflicts

Fighting hunger, malnutrition and poverty is most difficult in countries affected by protracted crises (Trend 7). These crises are driven by a combination of recurring causes: human-made factors and natural hazards that often occur simultaneously, violent conflict, lengthy periods of food crisis, the breakdown of livelihoods and food systems, and inadequate governance and institutional capacity to deal with the resulting impacts.

Almost half a billion people in more than 20 countries and territories, mostly in Africa, are affected by protracted crisis situations. Most of these people derive their food, income and well-being from agriculture and related sectors. Two-thirds of international humanitarian assistance, or 80 percent of the emergency funds provided by OECD member countries, has gone to alleviate protracted or recurrent crisis situations, which last on average eight or more years (Trends 7 and 15).

Conflicts, together with protracted crises and natural disasters, are major disablers of agriculture livelihoods, food security and nutrition. They also fuel displacement and migratory flows. In recent decades, the world has seen increased intensity and frequency of conflicts and disasters (Trends 7 and 11). More risk-informed, inclusive and equitable resilience and development processes will be essential to preventing and resolving rising conflicts around the world.

Challenge 9
Preventing transboundary and emerging agriculture and food system threats

Agriculture faces an alarming increase in the number and intensity of outbreaks of transboundary animal and plant pests and diseases. Food systems, in general, face threats to food safety, as well as the risk of radiation events (Trend 6). Climate change is in part responsible for the rise in food system emergencies (Trends 4 and 6).

Controlling transboundary plant pests and diseases reduces yield losses in crops and pastures and boosts productivity. This can be achieved through integrated pest management, which favours biopesticides and biocontrol agents that contain pest and disease risks safely. Transboundary animal diseases cause high rates of death and illness in animals. They continue to disrupt international and regional livestock markets and trade and pose a constant threat to the livelihoods of livestock farmers around the globe. Currently, the international community lacks the capacity and coordination to prevent, control and eradicate emerging transboundary animal diseases (Trend 6). Meeting changing food demand through intensive animal

production creates the risk of higher point-source pollution, increased use of antibiotics and potentially more serious epidemics of zoonotic diseases.

Food-borne diseases are an important cause of morbidity and mortality worldwide. However, the extent and cost of unsafe food and the burden arising from parasitic and chemical contaminants in food are still largely unknown. Food safety may be jeopardized further by unsafe water used in food processing, unsanitary food handling, inadequate storage facilities, and poorly enforced regulations. These risks are compounded by increasing antimicrobial resistance, which threatens the prevention and treatment of a range of infections (Trend 6). Antimicrobials are still heavily used not only to protect human and animal health, but also in the broader context of livestock and agricultural production.

Challenge 10

Addressing the need for coherent and effective national and international governance

Since the challenges facing food and agriculture are interconnected, addressing them will require integrated policy approaches at national and international levels. Designing such approaches will not be easy, given the past performance of sector-specific policy-making and the deficiencies in global and national governance mechanisms, regulatory systems, and monitoring and accountability (Trends 14 and 15).

The 2030 Agenda for Sustainable Development and related global agreements (see Annex) stress the interdependence of the challenges facing the global community on the path to sustainable development. They recognize the need to combine diverse actions to achieve linked objectives and that this combination will place new technical demands on policy-makers at all levels and new demands on institutional arrangements and coordination at various levels of governance. The related challenges include: combining instruments implemented at different levels of governance in ways that are mutually reinforcing, while containing inevitable trade-offs; and capitalizing on synergies among the Sustainable Development Goals (SDGs) and related targets, among different sectoral policies, and among the diverse stakeholders at local, municipal, provincial, national, regional and international levels. More inclusive governance will be needed to improve dialogue about the hard policy choices to be made. It is crucial to avoid the marginalization of the poor, who lack the political force to influence decisions, and progressively engage them in the development process (Trend 14).

Growing competition over natural resources can cause the rural poor to be dispossessed of the very foundation of their livelihoods, especially in protracted crisis situations and conflict and disaster-affected areas. A key governance challenge is ensuring the recognition of the poor's formal and informal rights of access to, and use of, natural resources through implementation of voluntary guidelines on the responsible governance of

tenure of land, fisheries and forests, and through support to the realization of the right to adequate food. Especially in areas that are vulnerable to the impacts of climate change and conflict and where institutions are fragile, improved natural resource governance, based on the concepts of governance of tenure, will be needed to establish a flexible framework for mitigating and resolving conflicts over land, water, fisheries and forests, protecting biodiversity, and ensuring ecosystem services.

International cooperation has an important role to play. Many resources upon which the agriculture sectors depend are transboundary in nature. Changes in the environment will lead to changes in resource availability, the migration of people and plant and animal species, and modifications in human activities. Extreme events, such as forest fires, species invasions, and pests and diseases, will cross national boundaries. Policies and institutions dedicated to the prevention and management of specific climate-related risks and vulnerabilities are mainly local and national, but they need to be more effectively supported by international cooperation and mechanisms.

Other areas requiring improved governance include: financing for inclusive food and agriculture development; meeting employment and migration challenges; addressing shortfalls in the multilateral trading regime in relation to food and agriculture systems; and providing open access to data and statistics to enhance the role of all stakeholders in governance.

Annex

International frameworks of relevance to FAO's work and mandates

The 2030 Agenda for Sustainable Development

The 2030 Agenda, which entered into effect on 1 January 2016, represents a paradigm shift in the world's vision, approach and ambitions for development. At the heart of the 2030 Agenda is an overarching normative commitment to 'leave no one behind'. This principle encapsulates the United Nations' distinctive commitment to social inclusion that includes gender equality and women's empowerment, the protection of the vulnerable, and the measurement of success through the lens of the impact on the least advantaged. It demands active efforts to address inequality and imposes a demanding test for all policy prescriptions.

In the areas of FAO's mandates, the policy aspirations of the new agenda are large and transformative: the eradication of poverty, hunger and malnutrition; the global transition to more sustainable food and agriculture, including an extensive commitment to the protection of biodiversity, the sustainable use of land, soils, fisheries, forests, mountains, oceans and water, and the reduction of food loss and waste; and a treaty commitment, backed by substantial resources, to take actions to hold global warming well below 2°C, while ensuring timely action to promote climate change adaptation and improve disaster risk reduction and climate resilience.

The Addis Ababa Action Agenda

This agenda addresses all sources of finance and covers cooperation on a range of issues including technology, science, innovation, trade and capacity building. While domestic resource mobilization is central to the agenda, commitments to Official Development Assistance were reaffirmed, particularly for the least developed countries, including pledges to increase South-South cooperation. The outcome document also underscores the importance of aligning private investment with sustainable development and establishing public policies and regulatory frameworks to set the right incentives. A new mechanism that will facilitate financing for new technologies for developing countries was also agreed upon.

The Paris Agreement on climate change

Adopted under the United Nations Framework Convention on Climate Change, the Paris Agreement will be implemented mainly through Nationally Determined Contributions towards climate change mitigation and adaptation. As part of the agreement, countries have committed to define a clear roadmap for ratcheting up climate finance to US$100 billion a year by 2020. Food and agricultural systems feature prominently in adaptation and mitigation efforts and will play an important role in the implementation of these national climate action plans, particularly in developing countries where the share of agriculture in total value added is significant.

Forests will also play an important role in the implementation of this milestone agreement, in both mitigation and adaptation efforts. The main mitigation mechanism is Reducing Emissions for Deforestation and Forest Degradation (REDD+). The agreement also acknowledges forests' potential for adaptation, including joint approaches and the importance of non-carbon benefits.

Climate regulation and carbon sequestration services provided by oceans, inland waters and aquatic ecosystems also feature prominently in the Agreement, highlighting the urgency of reversing current trends, restoring aquatic ecosystems and their productive capacity.

Second International Conference on Nutrition and the Decade of Action on Nutrition

At the Second International Conference on Nutrition (ICN2) in 2015, world leaders renewed their commitment to eradicate malnutrition and transform food systems so that they can make nutritious diets available to all. The Rome Declaration on Nutrition and the Framework for Action were adopted at ICN2. The Rome Declaration acknowledges the multiple challenges that malnutrition poses to inclusive and sustainable development and health. The Framework for Action provides a set of voluntary policy options and strategies, in the form of 60 recommended actions, to guide the implementation of the wide-ranging commitments stated in the Rome Declaration.

On 1 April 2016, the United Nations General Assembly proclaimed a UN Decade of Action on Nutrition that will run from 2016 to 2025, providing an umbrella framework for a wide group of actors to work together to implement the Framework for Action and address other pressing nutrition issues. FAO and WHO will lead the implementation of the Decade of Action on Nutrition in collaboration with UN agencies and other stakeholders.

World Conference on Disaster Risk Reduction and the Sendai Framework for Disaster Risk Reduction

The Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030 recognizes disaster risk reduction as an important component of sustainable development. It was adopted at the Third World Conference on Disaster Risk Reduction, held in Sendai in March 2015. The framework builds on the experiences of the Hyogo Framework for Action (2005–2015) and addresses the risks of all disasters, in both their geographic scale and time span, that are caused by natural and human-induced hazards as well as related environmental, technological and biological hazards and associated risks.

The Sendai Framework includes a number of notable innovations. These include, the shift to a wider multihazard risk management approach, which includes transboundary, technological and biological hazards and disasters; emphasis on multisectoral engagement in the planning and delivery of disaster risk reduction actions; and recognition of the importance of well-functioning health systems. Specific innovative elements of the SFDRR include the call for more coherent risk sensitive development policies for most vulnerable sector, including agriculture and food security, and the role of social safety-net mechanisms in the realm of food security and nutrition. The need to protect agriculture livelihoods and productive assets including livestock, working animals, tools and seeds are specifically referred.

UN Summit for Refugees and Migrants and other global developments on migration

Several global initiatives have been recently launched to address current migration patterns. Migration and human mobility are explicitly recognized in the 2030 Agenda, which establishes a number of migration-related targets across the SDGs. At the UN Summit for Refugees and Migrants, held on 19 September 2016, the international community stressed that greater emphasis should be put on addressing the root causes of large movements of refugees, the drivers of migration, international action and cooperation on refugees and migrants, and issues related to displacement. FAO has a role to play in: (i) exploring and enhancing the positive linkages between migration, food security, climate change, agricultural and rural transformation, and peace, stability and security; (ii) enhancing countries' capacities and policy coherence to address migration in specific policy areas (e.g. ending hunger, food insecurity and malnutrition; promoting rural employment opportunities for youth; better managing natural resources; improving access to social protection; promoting gender equality; strengthening rural organizations; disaster risk management); (iii) building community resilience in natural hazard-, disaster- and crisis-prone contexts by supporting sustainable agriculture livelihoods and reducing distress rural out-migration; and (iv) channelling additional funds in restoring land and sustainable livelihoods.

At the first World Humanitarian Summit, held in Istanbul in May 2016, UN agencies and programmes committed to transcend the humanitarian-development divide and reduce the human cost of disasters and protracted crises by building the resilience of people, communities and countries at risk or caught up in crises.

Habitat III – United Nations Conference on Housing and Sustainable Urban Development

The urbanization process and associated demographic changes are posing unprecedented challenges related to hunger, food insecurity and malnutrition in all its forms, which are becoming increasingly manifest in urban areas. Food security, malnutrition and hunger in urban areas are receiving growing attention worldwide and need to be recognized at international, national, subnational and local levels as key components of resilient and sustainable development in the urban environment.

In October 2016, Habitat III was convened to reinvigorate the global commitment to sustainable urbanization and focus on the implementation of a New Urban Agenda, which builds on the Habitat Agenda of Istanbul that was agreed on in 1996. At Habitat III, the international community agreed to pursue the New Urban Agenda. Food security and strengthening of urban-rural linkages were recognized as key elements for sustainable urban development.

Sector specific global developments

Port State Measures Agreement. The 2009 Agreement on to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA) entered into force in June 2016. The PSMA creates binding obligations and sets standards for the inspection of foreign vessels that seek to enter the port of another state. The measures allow a country to block ships it suspects of having engaged in illicit fishing and thereby prevent illegal catches from entering local and international markets. The FAO Committee on Fisheries identified the capacity development needs of developing states in the effective implementation of the PSMA.

World Forestry Congress. The main outcome of the XIV World Forestry Congress, held in Durban, South Africa in September 2015, was the Durban Declaration, which represents a new vision of forests and forestry for 2050. The vision links forest actions with efforts to achieve food security and integrates them with other forms of land use and efforts to combat climate change.

UNFF-11 Resolution. At its 11th session in 2015 the United Nations Forum on Forests (UNFF) agreed on a Ministerial declaration entitled 'The forests we want: beyond 2015' and a draft resolution on the 'International arrangement on forests beyond 2015'. The UNFF11 resolution, recommends extending the International Arrangement on Forests until 2030 and strengthening its work in supporting the sustainable management of the world's forests.

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Population growth, urbanization and ageing

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The purpose of this report is to increase understanding of the nature of the challenges that agriculture and food systems are facing now and will face into the 21st century. Its analysis of 15 global trends provides insights into what is at stake and what needs to be done. Most of the trends are strongly interdependent and, combined, inform a set of 10 challenges to achieving food security and nutrition for all and making agriculture sustainable. 'Business-as-usual' is not an option. Major transformations in agricultural systems, rural economies and natural resource management will be needed if we are to realize the full potential of food and agriculture to ensure a secure and healthy future for all people and the entire planet.

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