Food and Agriculture Organization of the United Nations

2

The future of food and agriculture

Alternative pathways to 2050

SUMMARY VERSION

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ABBREVIATIONS

AfDB	African Development Bank
BAU	Business as usual scenario
CFS	Committee on World Food Security
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalent
COP21	Twenty-first Conference of the Parties of the United Nations Framework Convention on Climate Change (Paris, 2015)
EAP	East Asia and the Pacific
ECA	Europe and Central Asia
ENVISAGE	Environmental Impact and Sustainability Applied General Equilibrium model
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign direct investment
GAEZ	Global Agro-Ecological Zones (FAO-IIASA)
GAPS	Global Agriculture Perspectives System (FAO)
GHG	Greenhouse gasses
GLEAM	Global Livestock Environmental Assessment Model (FAO)
GTAP	Global Trade Analysis Project
$GtCO_2$eq	Gigatonnes carbon dioxide equivalent
HIC	High-income countries
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IIASA	International Institute for Applied Systems Analysis
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
Kcal	Kilocalories
LAC	Latin America and the Caribbean
LMIC	Low- and middle-income countries
NNA	Near East and North Africa

OCHA	United Nations Office for the Coordination of Humanitarian Affairs
ODA	Official development assistance
OECD	Organisation for Economic Co-operation and Development
PoU	Prevalence of Undernourishment
RCP	Representative Concentration Pathway
SAS	South Asia
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
SSP	Shared Socio-economic Pathways
SSS	Stratified societies scenario
TSS	Towards sustainability scenario
UN	United Nations
UNECA	United Nations Economic Commission for Africa
UNICEF	United Nations Children's Fund
USD	United States dollar
WFP	World Food Programme
WHO	World Health Organization
WRI	World Resources Institute

FOREWORD

The last century has seen great socio-economic progress and significant welfare improvements worldwide. However, a world of "freedom from fear and want", as envisioned by the founders of the United Nations, has yet to be achieved.

Much also remains to be done to fulfil FAO's vision of creating "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".

Progress towards eliminating hunger and malnutrition is still insufficient to meet the goals of the 2030 Agenda for Sustainable Development

Addressing the challenges of hunger, food insecurity and malnutrition in all its forms features prominently in the targets of the second Sustainable Development Goal (SDG) of the 2030 Agenda for Sustainable Development. However, despite great progress towards increasing income and wealth globally, billions of people still face pervasive poverty, hunger and malnutrition, and various dimensions of inequality, joblessness, disease and deprivation from vital goods and services. FAO's most recent estimates indicate that 821 million people, approximately one out of every nine people in the world, were undernourished in 2017. Worse still, after a prolonged decline, both the absolute number of undernourished people and the prevalence of undernourishment (PoU) have started increasing again, signalling a possible reversal of trends. At the same time, food insecurity is contributing to undernutrition, as well as overweight and obesity, and high rates of these forms of malnutrition coexist in many countries.

Agriculture, including fisheries and forestry, is far from being sustainable

Much of humanity's progress has come at considerable cost to the environment. To produce more food and other non-food agricultural goods, a combination of intensified agricultural production processes and the clearing of forests has led to the degradation of natural resources and is contributing to climate change.

Should we continue to address these challenges with a "business as usual" approach, the future will not look promising. Sustainable food and agricultural systems cannot be achieved without significant additional efforts.

Still, options to face these challenges are available

Options to face these challenges exist, but they need to be considered carefully. Food and agriculture systems may follow alternative pathways, depending on the evolution of a variety of factors such as population growth, dietary choices, technological progress, income distribution, the state and use of natural resources, climatic changes and efforts to prevent and resolve conflicts. These pathways can and will be impacted by strategic choices and policy decisions. Swift and purposeful actions are needed to ensure the sustainability of food and agriculture systems in the long run. The future is uncertain, but to act now, we need a good sense of what the world may look like under potentially different pathways.

This report explores different future pathways for food and agriculture systems through three distinct scenarios characterized by the way the key challenges to food security, nutrition and sustainability are dealt with: boldly, partially or not at all. It improves our ex ante understanding of alternative future long-term trends, both globally and at the regional level, of key variables and indicators affecting the future of food and agriculture. On the basis of these findings, the report highlights possible strategic options to guide food and agricultural systems along a more socially, environmentally and economically sustainable path.

This report shows convincingly, on the basis of quantitative evidence, that we can achieve more with less, and produce safe and nutritious food for all, while containing the expansion of agricultural sectors and hence limit the use of natural resources.

The purpose of this publication is to bridge a knowledge gap regarding the future of food and agriculture at a time when countries, international organizations, civil society and academia are increasingly requesting an authoritative foresight exercise in this domain. This work catalyses a wealth of multidisciplinary expertise and draws on many different data sources, from both inside and outside FAO. In rigorous but accessible language, the report sheds light on our responsibilities in shaping our common future.

Decision makers, the international community, academia and civil society are invited to give this report due consideration, not as the end point of an analytical endeavor, but rather as

FOREWORD

the starting point for a dialogue on strategic policy choices and processes aimed at shaping sustainable development patterns at country, regional and global levels.

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The future of food and agriculture: the overarching concern and key messages

The future of food and agriculture: the overarching concern and key messages

The future of food and agriculture[1] faces uncertainties that give rise to serious questions and concerns regarding its performance and sustainability. Uncertainties revolve around different factors, including population growth, dietary choices, technological progress, income distribution, the state of natural resources, climate change, the sustainability of peace, etc. Nobody knows with precision how these factors will evolve over time; however, they are certain to shape the future. For this reason, countries, international organizations, civil society and academia are increasingly requesting an authoritative foresight exercise that outlines alternative scenarios and highlights potential pathways for food and agricultural systems.

This publication bridges the knowledge gap regarding the future of food and agriculture. It does not provide a detailed list of specific policy measures to achieve an ideal future, which is beyond the scope of a global long-term foresight exercise. Rather, this report highlights global challenges for the future of food and agricultural systems, and discusses how tackling these challenges – or leaving them unaddressed – will affect the sustainability of food and agricultural systems. The analysis is quantitative in nature, given the need to substantiate the possible scenarios with quantitative long-term projections of food and agriculture. At the same time, the interpretation of the quantitative findings relies on extensive qualitative analysis.

The analysis of the alternative scenarios detailed in this report addresses fundamental questions regarding the future of food and agriculture; it supports the identification of strategic orientations that nurture national, regional and global dialogues and policymaking processes, and helps shape key messages to guide food and agricultural systems along sustainable pathways.

[1] In this report, "agriculture" comprises all agricultural sectors, including crops, livestock, fisheries and forestry.

WILL GLOBAL FOOD AND AGRICULTURAL SYSTEMS BE ABLE TO FEED HUMANITY SUSTAINABLY AND SATISFACTORILY IN THE FUTURE, WHILE ALSO ACCOMMODATING ADDITIONAL NON-FOOD AGRICULTURAL DEMAND?

KEY MESSAGES

Food and agricultural systems are affected by trends that could jeopardize their future sustainability. Population and income growth drive the demand for food and bring about changes in people's dietary preferences. Persistent poverty, inequality and unemployment constrain access to food and hamper the achievement of food security and nutrition goals. Agricultural production is limited by the increasing scarcity and diminishing quality of land and water resources, as well as by insufficient investment in sustainable agriculture. Climate change is increasingly affecting yields and rural livelihoods, while agriculture continues to emit large amounts of greenhouse gases (GHGs).

Changing course is critical – "business as usual" is no longer an option. If food and agricultural systems remain on their current path, the evidence points to a future characterized by persistent food insecurity and unsustainable economic growth. Many countries and regions are already committed to increasing the sustainability of their food and agriculture systems. However, fully meeting Sustainable Development Goals (SDGs) targets, as envisaged by the 2030 Agenda for Sustainable Development, will require additional efforts to address growing inequalities and gender imbalances, sustain peace, reduce GHG emissions, avoid resource depleting farming systems, manage the demand for resource-intensive animal food products, and reduce food loss and waste, among other challenges.

A more sustainable future is attainable, but getting there will not be easy. To move away from "business as usual", all societies will be required to renew the assets used to produce goods and services, or capital stock, develop new solutions, and implement innovative technologies. In the spirit of solidarity enshrined in the SDGs, countries and social groups that can reasonably shoulder the costs involved in the necessary transformations have to provide support to those already affected by the negative effects of unsustainable development, and help them prepare a better future for the next generations.

The future of food and agriculture: the overarching concern and key messages

All countries must commit to responsibility-sharing in implementing fundamental changes.
The global transformative process required to improve the sustainability of food and agriculture transcends the divide between "developed" and "developing" countries. All countries will be affected in this process, as "fundamental changes in the way societies consume and produce are indispensable for achieving global sustainable development" (Rio+20. *The future we want*).

Raising consumer awareness will help contain the need to unnecessarily expand food production and reduce the "triple burden" of malnutrition …
Agricultural production is expected to rise worldwide in response to population growth, dietary changes and increased incomes. Raising consumer awareness about environmentally sustainable and healthier diets, reducing food waste, pricing food to reflect the negative externalities of its production, and limiting the use of grains for biofuel production will all be critical to curb the demand for agricultural products. These actions will also be critical to reduce the "triple burden" of malnutrition that is, undernourishment, micronutrient deficiencies, and overweight and obesity, that often exist within a single country or even community.

… but producing more will be unavoidable, and the way forward is doing so with less.
Those working in food and agriculture must learn how to satisfy a growing demand under more significant resource constraints by improving land and water use, reducing GHG emissions, increasing efficiency in energy production and consumption, and restoring soils and forests. These are just some of the variety of strategic options to consider in search of sustainability.

While moving towards sustainability, food prices might increase significantly …
If the entire range of production and consumption costs is taken into account, including resource degradation and GHG emissions, evidence indicates that food prices are likely to increase significantly. Such increases could lead to a more careful use of both natural resources and of food itself.

… yet environmental sustainability and food security can still go hand in hand.
While moving food and agricultural systems towards sustainability may drive up food prices and restrain global agricultural output, the per capita food availability and access to food in low- and middle-income countries can improve substantially if a more

equitable distribution of income within and across countries is pursued.

A more equitable income distribution is a must …

Ensuring a more equitable distribution of income within and across countries is indispensable in the quest for food security, better nutrition and the environmental sustainability of food systems. Among the strategic options to achieve this goal are: promoting sustainable technologies; facilitating the access to markets for family farmers; building stronger institutions to ensure competitive, transparent and fair markets for agricultural inputs and outputs; implementing effective social protection schemes and equitable fiscal systems; and reducing illicit financial flows that drain resources from low-income countries.

… and requires strengthening access to assets for vulnerable groups.

Secure and equitable access to assets such as land, water, capital and credit will, together with improved information and enhanced skills and know-how, significantly improve the earning potential of the poorer segments of society. This is true for both people who will remain engaged in agricultural activities and for those who will move out of agriculture to engage in other productive sectors.

Food and agricultural sectors are key, but are no longer enough on their own to ensure equitable access to food.

Crops, livestock, fisheries and forestry continue to be important for employment and income generation in low- and middle-income countries. However, these sectors alone no longer provide enough jobs or income-earning opportunities.

On the one hand, agriculture and family farming in particular, must be more firmly linked to the broader rural and urban economy. This can be done by developing agro-industries and setting up infrastructure to connect rural areas, small cities and towns. On the other hand, strong institutions supported by efficient fiscal systems, are needed to ensure economy-wide income-earning opportunities, effective social protection, and competitive and equitable domestic and international markets for inputs and outputs.

All these aspects are critical to improve the efficiency and equity of economic systems and facilitate their structural transformation.

In addition, interventions to reduce GHG emissions in agriculture will not pay off significantly if efforts to boost energy-use efficiency are not simultaneously undertaken on an economy-wide basis.

1. OVERVIEW

The future of food and agriculture – Alternative pathways to 2050 provides a forward-looking perspective on the development of global and regional food and agricultural systems. This development, and its related challenges, will depend on underlying long-run trends in supply and demand, which will continue to shape global food and agriculture.

The overarching concern regarding the future of food and agriculture is whether global systems will be able to sustainably feed humanity up to 2050 and beyond, while at the same time accommodating the demand for non-food agricultural commodities. This concern arises because current trends are calling into question the economic, social and environmental sustainability of food and agricultural systems.

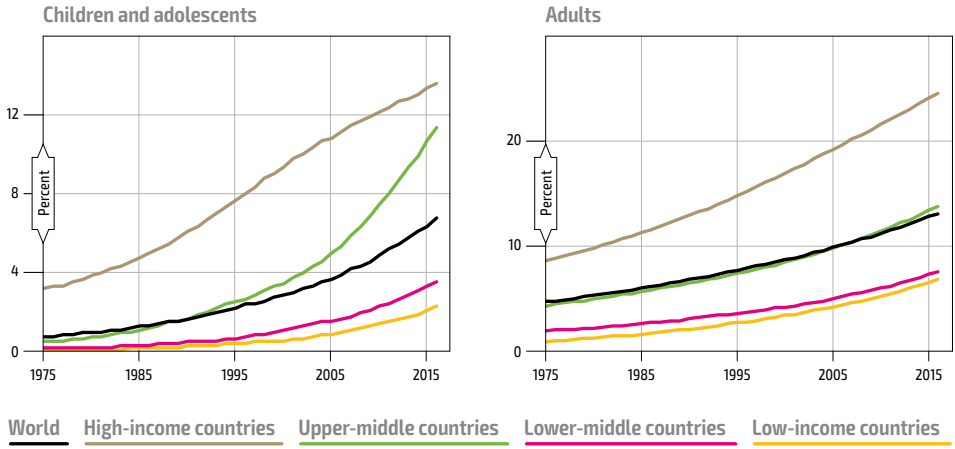
Increased population, income and urbanization, all drive up the demand for food and change people's dietary preferences towards more resource-intensive animal products and processed food.
The global demand for food and non-food agricultural products continues to grow, reflecting dietary changes, driven by population growth, a rise in income and increased urbanization. For example, the share of meat and dairy products in people's diets has increased with economic growth, while the share of cereals has diminished. This has prompted concerns about the sustainability of diets, as well as about their health implications, particularly – but not exclusively – in high-income countries (HIC) where both adult and child obesity show a dramatic increasing trend (Figure 1.6).[2] At the same time, the incidence of diet-related non-communicable diseases is on the rise (GBD 2015 Risk Factors Collaborators, 2016; GBD 2016 DALYs and HALE Collaborators, 2017).[3]

Persistent poverty, inequality and unemployment constrain the access to food and hamper the achievement of food security and nutrition goals.
The unequal distribution of income and access to assets, persistent extreme poverty and the lack of earning opportunities for hundreds of millions of people cause food insecurity to persist. While much progress was made over the past years to reduce hunger, more than 821 million people are still chronically hungry, and the evidence points to persistent undernourishment in the future (Figure 1.7). More than two billion people suffer from various forms of micronutrient deficiencies. For example, more than 600 million women of reproductive age still suffer from anaemia, which is often caused by iron deficiency, while several

[2] The numbering of the figures in this summary version retains that of the main publication, although it is not consecutive since not all the figures are used here.

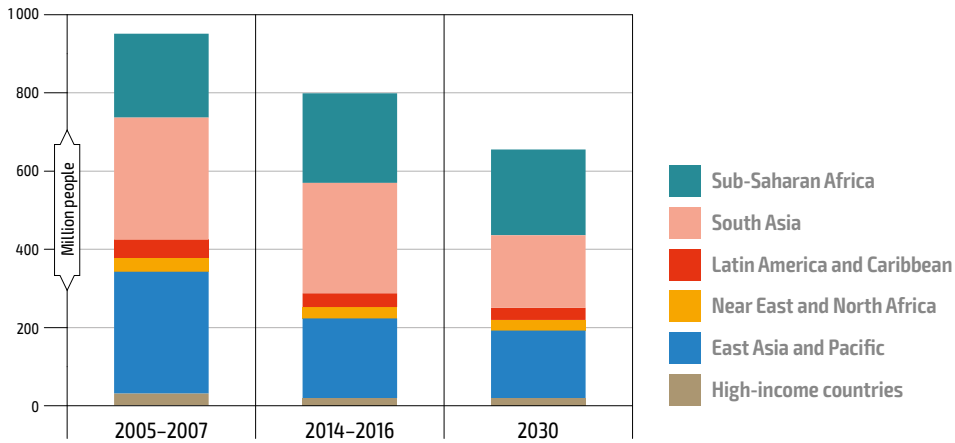
[3] Please refer to the report – of which this is the summary – for reference entries.

FIGURE 1.6 PREVALENCE OF OBESITY AMONG CHILDREN AND ADULTS BY REGION



Note: Regions are arranged into income groups as defined in WHO Global Health Observatory data (WHO, 2018). Children and adolescents are those between 5 and 18 years of age, adults are those aged 18 and above.
Source: WHO. 2018. Overweight and obesity. In: ***WHO Global Health Observatory data, overweight and obesity*** [online]. Geneva, Switzerland. www.who.int/gho/ncd/risk_factors/overweight

FIGURE 1.7 UNDERNOURISHMENT UNDER A BUSINESS AS USUAL SCENARIO, 2005–2030



Source: FAO. 2017a. ***The future of food and agriculture - Trends and challenges.*** Rome. For the periods 2005–2007 and 2014–16 data are based on FAO, IFAD and WFP. 2015a. ***The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress.*** Rome, FAO; for year 2030 data are based on FAO, IFAD and WFP. 2015b. ***Achieving Zero Hunger. The critical role of investment in social protection and agriculture.*** Rome.

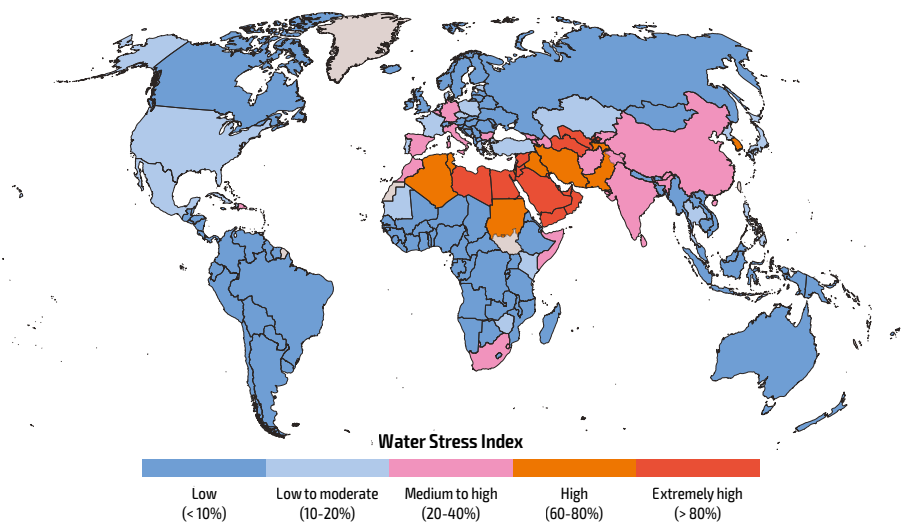
hundred thousands of children go blind every year due to vitamin A deficiency.

Persisting inequalities other than those relating to income – including access to resources such as land and water, or to the benefits that high-value resources such as oil and minerals generate – not only force people to live in an unfair world, but also trigger conflicts that in turn can exacerbate extreme poverty and food insecurity. Indeed, the marked surge in the number of global conflicts observed during the last decade is a major driver of food insecurity and malnutrition (FAO, IFAD, UNICEF, WFP and WHO, 2017) and conflict-induced negative impacts on human welfare are no longer limited to specific regions.[4]

Agricultural production is constrained by the increased scarcity and diminished quality of land and water resources. What can be produced and whether growing and changing food

[4] Rather, such impacts have become a global issue with the displacement of people and migration, such as in the case of the ongoing civil war in the Syrian Arab Republic. Conflicts, violence and natural disasters are among the root causes of migration and forced displacement. However, many migrants are forced to move because of socio-economic factors including poverty, food insecurity, a lack of employment opportunities, limited access to social protection, natural resource depletion, and the adverse impacts of environmental degradation and climate change.

FIGURE 1.11 **FRESHWATER WITHDRAWALS AS A PERCENTAGE OF TOTAL RENEWABLE WATER RESOURCES**



Note: Countries are considered water-stressed if they withdraw more than 25 percent of their renewable freshwater resources. The countries approach physical water scarcity when more than 60 percent of their water is withdrawn, and face severe physical water scarcity when more than 75 percent is withdrawn.
Source: FAO Global Perspectives Studies, based on FAO AQUASTAT (various years).

requirements can be met will depend on the availability and productivity of resources, and notably of land and water. These resources are already under pressure (Figure 1.11), and although technical progress has raised productivity, evidence suggests that productivity growth, or at least growth in crop yields, is slowing. Moreover, food loss and waste put unnecessary pressure on land, water and energy resources along the food value chain; addressing this will improve environmental sustainability throughout the food system.

Unless supported by adequate investments, technical changes in food and agricultural systems will not lead to sustainable productivity improvements.

Questions arise as to whether the future demand for agricultural products will be compatible with the urgent need for greater sustainability in resource use. To meet the increasing demand for agricultural products in a more sustainable way, food and agricultural systems need more investment, including in research and development, to promote technical change. This is especially true for regions that currently lag behind in productivity and are also among the most food-insecure, such as sub-Saharan Africa. However, financing for investment is limited and priorities need to be identified to achieve productivity improvements that are sustainable in social, environmental and economic terms.

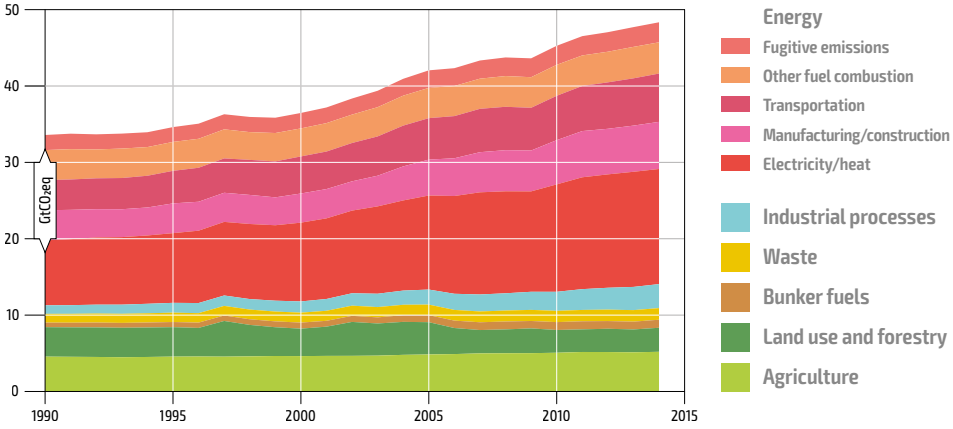
Unaddressed climate change is increasingly affecting yields and rural livelihoods, while food and agricultural systems, as well as the economy at large, continues to emit GHGs.

Climate change manifesting itself in the form of extreme weather events already negatively affects yields in crop production, livestock rearing and fisheries, particularly in low- and middle-income countries (LMIC). This adds pressure on natural resources and shifts the distribution of what can be produced and where. The fact that GHGs from human activities are the most significant driver of climate change observed since the mid-20th century is problematic. Food and agricultural systems are among the major contributors to GHG emissions, and are therefore crucial to efforts towards the mitigation of climate change. Changes in agricultural production systems aimed at climate change mitigation and adaptation would be expected to reverberate positively throughout food systems. So far, GHG emissions within the economy at large have not been reduced (Figure 1.15). This implies that the agriculture sector needs to adapt to climate change, while climate change needs to be mitigated.

Understanding the possible pathways towards sustainability in the face of these challenges necessitates a long-term foresight exercise with alternative scenarios.

No doubt, the challenges for global food and agricultural systems discussed above provide grounds

FIGURE 1.15 **ANNUAL GREENHOUSE GAS EMISSIONS BY SECTOR, 1990–2014**



Note: "Bunker fuels" refers to emissions from international aviation and maritime transport. "Other fuel combustion" includes biomass combustion, and stationary and mobile sources. "Fugitive emissions" refers to flaring of gas and emissions from coal mining. "Waste" includes emissions from landfills, wastewater treatment, human sewage and other waste.
Source: WRI. 2014. *Climate Analysis Indicators Tool (CAIT): WRI's Climate Data Explorer.* Washington, DC.

for concern and raise questions about how to face them if we want to move towards sustainability, or what is at stake if we move in the opposite direction. The challenges are complex and diverse. While some of them are inherent to food and agricultural systems and depend on the way in which these systems are – and will be – organized (e.g. increasing pressure on land, water and energy use), others are essentially systemic, impacting food and agricultural systems from elsewhere (e.g. economy-wide unemployment, conflicts, climate change, urbanization and migration). Additional complexities arise because inherent and systemic challenges may be intertwined, displaying incremental and multiplicative effects in the medium- to long-run. Together, these challenges create an uncertain future for food and agriculture.

A long-term foresight analysis is needed to understand the evolution of global food and agricultural systems against a background of multiple uncertainties, depending on our ability (or lack thereof) to face the various challenges. The core of this foresight exercise is to compare alternative scenarios in which these challenges are tackled to different degrees. This comparison helps understand the potential implications of the strategic options and interventions underlying each scenario for food and agricultural systems.

In a study such as this one, the scenarios are not forecasts or predictions, or even stand-alone projections, but rather possible, plausible and consistent pathways of what the future might look like at some, usually distant, point in time. Pathways differ depending on the evolution and interaction of the many factors that determine the dynamics and performance of socio-economic and environmental systems, such as income growth and distribution, population trends and demographic changes, technology, agroecological conditions and natural resources, GHG emissions and climate change. These factors may evolve depending on different policies and interventions. The objective of the foresight exercise is therefore not necessarily to obtain the most precise future estimates of food and agriculture variables, but rather to depict comprehensive and consistent frameworks that highlight how certain decisions can influence the unfolding of development pathways.

In many instances, a foresight analysis provides a scenario that essentially builds on past long-term trends of the factors that determine the dynamics and performance of socio-economic and environmental systems. Such a scenario is typically regarded as a "business as usual" and often considered as a "baseline" against which alternative scenarios are compared. Past trends already capture the observed impacts of a host of contingent, short-term events, such as temporary economic downturns, climate extremes, price spikes or reductions, international trade crises, local surges of pests and diseases, or temporary social unrest and conflicts, among others. Naturally, a long-term foresight analysis is unable to predict the future occurrence of such contingent, short-term events. Nonetheless, the holistic analysis does help identify "weak signals" of changes that are already present in the current situation. Such changes may progressively increase in magnitude or frequency in the future, and may potentially lead to significant shifts, for example in consumer preferences, technological changes or natural resource use.

This report presents a foresight exercise that builds on the expertise, skills and data of FAO and its partners, to help inform decision-making processes.

The methodology of this report is different from that of previous FAO exercises, which provided agricultural projections based on a single scenario. Building upon the FAO report *The future of food and agriculture – Trends and challenges* (FAO, 2017a), which highlighted how recent trends in key variables present challenges for food security and nutrition, the present report explores three different scenarios based on alternative trends for key drivers of the future of food and agriculture, including income

increase and distribution, population growth, technical progress in agriculture and climate change.

The report provides quantitative and qualitative analyses of challenges facing food and agricultural sectors. The quantitative analysis relies on both economy-wide and sector-specific simulation models. For each scenario at the regional and global levels, the results of the model-based exercise provide separate and comparative (across scenarios) analyses of key variables and indicators, including the share of agriculture in total value added, the supply and demand for a set of food and agricultural products, long-term price trends, performance in the field of food security and nutrition, natural resource use, the net trade positions of various regions for selected groups of products, and GHG emissions.[5]

The analysis of the scenarios led to quantitative findings that were scrutinized also in light of complementary qualitative analyses. The latter were developed on the basis of existing background studies and other literature in specific domains including food demand, natural resource use and GHG emissions, as well as on reports by FAO and other organizations investigating challenges to food security and nutrition in all its dimensions.

This report is the result of a corporate process led by FAO's Global Perspectives Studies team that relied heavily on in-house expertise, skills and data, but also involved partnerships with external institutions. It builds upon the experience gained in foresight exercises by colleagues from FAO and from other international institutions including the International Fund for Agricultural Development (IFAD), the Organisation for Economic Co-operation and Development (OECD), the International Food Policy Research Institute (IFPRI) and the European Union, and upon knowledge and practices developed by the international community to support the work of the Intergovernmental Panel on Climate Change (IPCC), to name but a few.[6] The report forms part of FAO's efforts to provide evidence-based support to decision-making processes. Therefore, it should be seen as a comprehensive assessment of alternative prospects of food and agricultural sectors that without any pretense to be exhaustive, goes well beyond mere model-based projections and aims to contribute to the foresight work of the international community at the science-policy interface.

This report was much needed to bridge a knowledge gap regarding the long-term future of food and agriculture. For the first time, a report

[5] Supplementary material including detailed commodity balances and other statistical tables is available online at: www.fao.org/3/CA1564EN/CA1564EN.pdf

[6] Annex I of the report provides a comparative review of the key foresight exercises that inspired this publication.

provides a globally consistent foresight exercise based on scenarios designed specifically to investigate challenges for food security and nutrition, while taking into account the future economy-wide context and possible climate change pathways. In accurate but accessible language, the report provides solid evidence regarding possible strategic options and directions to achieve the SDGs of eradicating hunger, improving nutrition and ensuring the sustainability of agriculture. Therefore, it helps understand how to move towards "a world in which food is nutritious and accessible for everyone and natural resources are managed in a way that maintain ecosystem functions to support current as well as future human needs" (FAO, 2014). Hopefully, this publication will be of use to everyone interested in long-term foresight assessments of global food and agricultural systems, including decision-makers and analysts in governments, international organizations, civil society organizations, the private sector, and academic and research institutions

2. ALTERNATIVE SCENARIOS FOR POSSIBLE FUTURES

As the future is uncertain, foresight exercises usually consist of the analysis of selected alternative scenarios that represent different futures against a range of uncertainties. These scenarios are generated in various ways, for example by giving prominence to historical trends; by assuming that existing challenges are tackled to different degrees, while adding expert judgement to form plausible narratives; or by emphasizing and magnifying one or more "weak signals" of change that are already detected in the current situation.

While consensus about plausibility may be an important element to take into consideration when designing scenarios, a much more important feature to consider is their internal consistency. Indeed, cause–effect nexuses must be carefully designed based on existent evidence-based knowledge, and due consideration must be given to the interdependence among the different elements of a scenario.

Based on those principles, three scenarios were designed for the foresight exercise at the centre of this report. Each scenario delineates an alternative future from 2012, the base year, to 2050.[7]

The first is a "business as usual" (BAU) scenario mostly characterized by a continuation of past trends and policy directions. This scenario is designed to help understand what the world would look like should outstanding challenges for food and agricultural systems remain unaddressed. Under the BAU scenario, the global economy grows at moderate rates, with significant disparities across regions (represented by the yellow lines in Figure 3.3). Moreover, significant inequalities persist within societies in terms of income, earning opportunities and access to basic goods and services. Consumers in HIC maintain their preferences for resource-intensive food, including animal products. In LMIC, the relatively limited income expansion does not favour a transition towards healthier diets, despite some convergence towards the caloric consumption levels of HIC.

Limited investments are undertaken to increase the sustainability of food and agricultural systems, as well as

[7] The scenarios were developed using a modelling framework. Two economic models provided the relevant projections for the scenarios: the FAO Global Agriculture Perspectives System (GAPS), a partial equilibrium model, and the Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) model. These two models were used because each of them produces complementary information. Together, the models provide a consistent framework for the construction of scenario simulations by ensuring that certain physical and economic balances are maintained, and theoretical requirements are met.

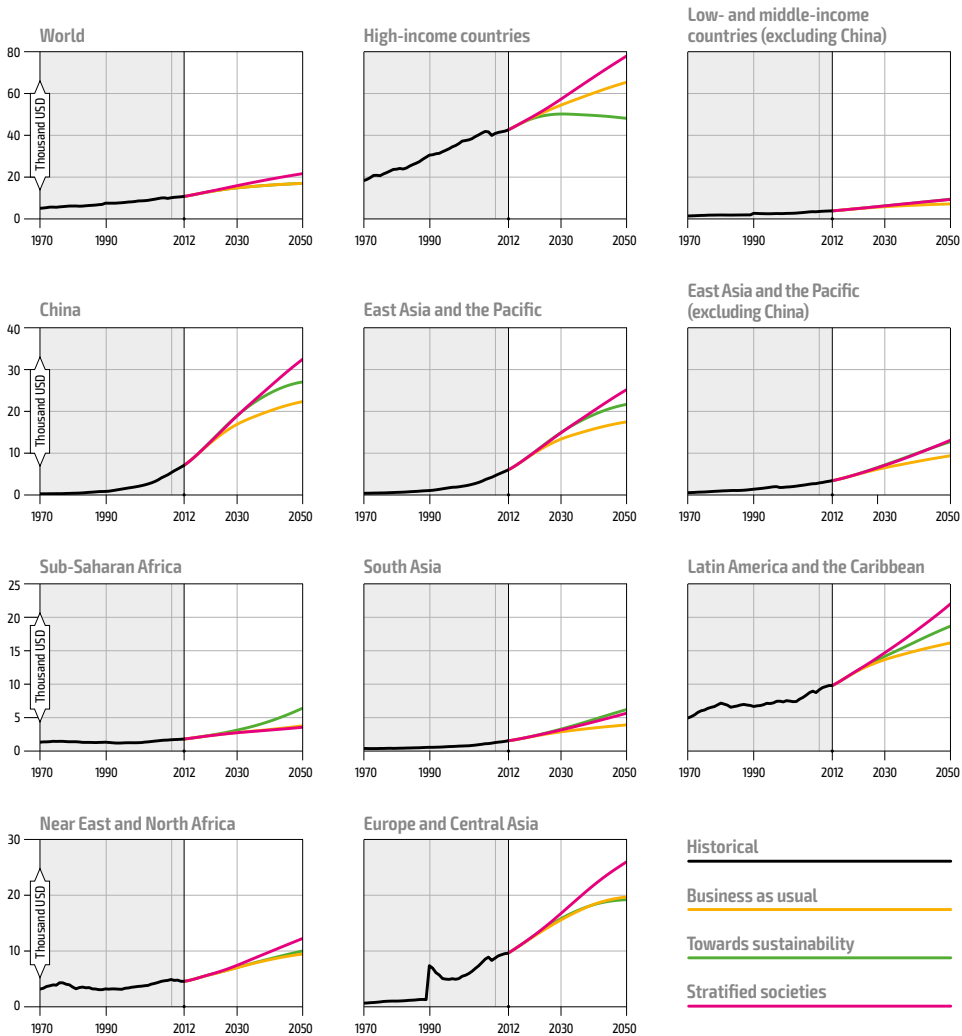
of other sectors of the economy, such as the energy sector. GHG emissions therefore keep rising, and climate change is only partially mitigated.

The second scenario is called "towards sustainability" (TSS). It is designed to help understand which proactive changes are needed to build more sustainable food and agricultural systems. Under this scenario, the global economy grows at moderate rates, as under the BAU scenario. However, income, earning opportunities and access to basic goods and services are more equitably distributed across countries and layers of societies thanks to proactive policies that are implemented as soon as possible, with improved governance and stronger national and international institutions (green lines in Figure 3.3). Diets in HIC shift towards a higher intake of fruits and vegetables and a lower intake of animal products due to a rising consumer awareness regarding sustainability issues, while income growth in LMIC favours more balanced diets than in BAU. Not only do consumers adopt more sustainable diets; they also take action to reduce waste. Significant investments are undertaken to increase the environmental sustainability of food and agricultural systems, as well as of other sectors of the economy. This leads to an increased efficiency in the use of natural resources and reductions in post-harvest losses. GHG emissions are progressively reduced to help realize stronger climate change mitigation than under the BAU scenario.

The third scenario is called the "stratified societies" scenario (SSS). It describes a future of exacerbated inequalities in terms of income, earning opportunities and access to essential goods and services across countries and layers of societies. Under this bleaker scenario, the global economy grows at faster rates than under the other two scenarios. However, selected regions – and particularly sub-Saharan Africa (SSA) – do not benefit significantly from this faster growth (red lines in Figure 3.3). Income, earning opportunities and access to goods and services are increasingly skewed to the advantage of elites, leaving large pockets of marginalized people. Consumption preferences tilt towards more animal products everywhere, while food waste increases, particularly in HIC. Limited or no investments are made to increase the sustainability of food and agricultural systems or of other sectors of the economy, particularly in low-income countries. As a consequence, the depletion and inefficient use of natural resources increases, as does food loss at all levels of the food value chain. GHG emissions also rise, leading to exacerbated climate change with severe impacts on human activities and the environment.

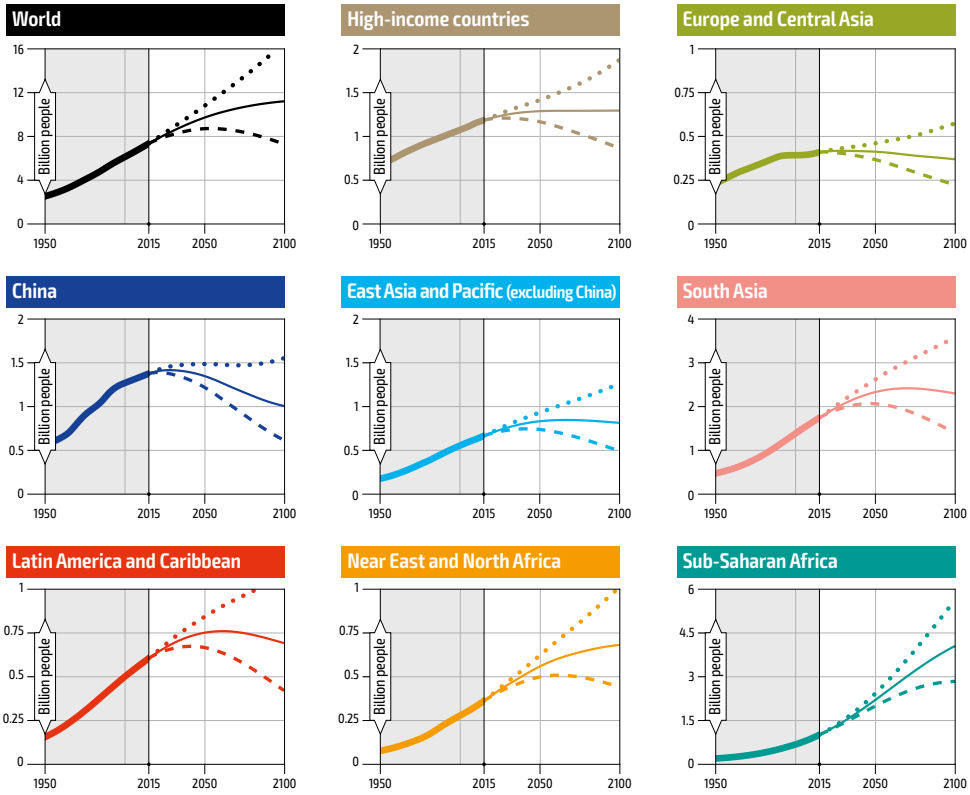
Demographic trends have a great impact upon the results of scenario-based foresight analysis.

FIGURE 3.3 **PER CAPITA GROSS DOMESTIC AND WORLD PRODUCT: HISTORICAL TRENDS AND PROJECTIONS (2012 EXCHANGE RATES)**



Notes: Country grouping is based on the World Bank Country Groups of July 2016, downloaded on 2 August 2016 from http://databank.worldbank.org/data/download/site-content/CLASS.xls as specified in Annex III, Table A 3.4 of the report. High-income countries (HIC) are classified in a single group, regardless of their geographical location. All other countries, qualified as low- and middle-income countries (LMIC), are classified by geographical region, notably Europe and Central Asia (ECA), East Asia and the Pacific (EAP), South Asia (SAS), Latin America and the Caribbean (LAC), Near East and North Africa (NNA) and sub-Saharan Africa (SSA). If not otherwise specified, LMIC and EAP include China (mainland only). Country groups and China are hereafter generally referred to as "regions".
Sources: FAO Global Perspectives Studies, based on data from the United Nations System of National Accounts (UN, 2016) for the 1990–2012 period; and the Shared Socio-economic Pathways (SSP) database version 1.1, OECD projections of gross domestic product (SSP database, 2016) for the 2013–2050 period.

FIGURE 1.2 GLOBAL POPULATION BY REGION: HISTORICAL AND PROJECTED, 1950–2100



Note: This report uses the 2015 revision instead of the more recent 2017 one, which was not yet available at the time of the running of the scenario simulations. No significant differences in the results of the scenario analysis are to be expected.

Source: United Nations. 2015. ***World Population Prospects: The 2015 Revision***. Department of Economic and Social Affairs, Population Division. New York, USA.

The demographic projections used in this report place the world population at almost 10 billion people in 2050, with significant regional disparities in growth patterns (Figure 1.2). These projections also indicate increasing proportions of the population residing in urban areas (Figure 1.3).

The different food requirements of young and old people, as well as the different consumption patterns of urban and rural populations, are going to affect the demand for and quality of various food items and minimum dietary energy requirements, which are linked to job type and living environment. Therefore, population dynamics will critically determine food demand as well as labour supply in the future.

All three scenarios share the same population projections to facilitate cross-scenario comparisons and emphasize the interplay between economic growth, equality and the availability of natural resources. Nonetheless, given all the other key differences that defined each scenario, including trends and strategic socio-economic and environmental directions, as explained the three scenarios display different degrees of challenges for food availability, access, stability and utilization, as well as for achieving nutrition targets and the overall sustainability of food and agricultural systems. Indeed, the magnitude of the challenges for food security and nutrition is different for each scenario because governments, the international community, civil society organizations, associations, consumers and producers take strategic decisions and adopt policies and/or behaviours that amplify – or mitigate – these challenges. Under the TSS scenario, for example, challenges to food security, nutrition and the sustainability of agricultural systems at large are less severe than under the other two scenarios because specific strategic directions are followed, and policy measures are undertaken to address them (Figure 2.3).

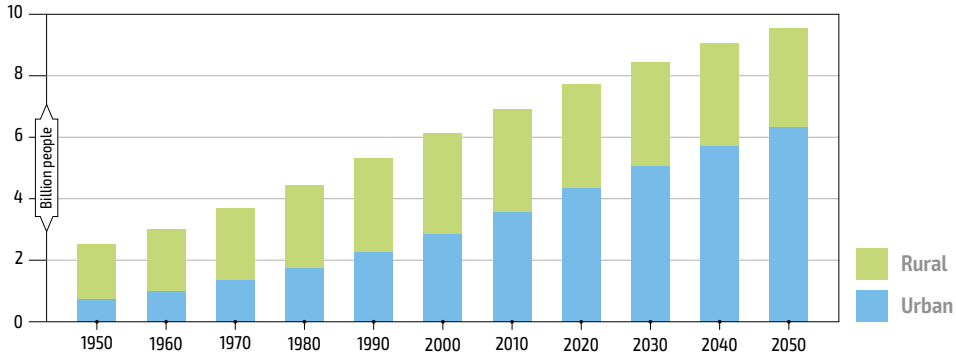
The three scenarios thus help address the overarching concern regarding the future of food and agricultural systems: will these systems be able, by 2050, to provide nutritious diets in a sustainable manner to almost 10 billion people who increasingly require resource-intensive food, while at the same time accommodating the demand for non-food agricultural commodities?

This overarching concern raises some further questions, namely: what can be done to manage food demand and change people's dietary preferences? How can society sustainably address the reduced availability and quality of land and water resources, particularly in regions where those resources are increasingly stressed? Will poverty, inequality and unemployment continue to constrain food access and hamper the achievement of food security and nutrition goals?

How will climate change affect agricultural sectors and rural livelihoods, and can the agricultural sectors reduce the GHGs they emit?

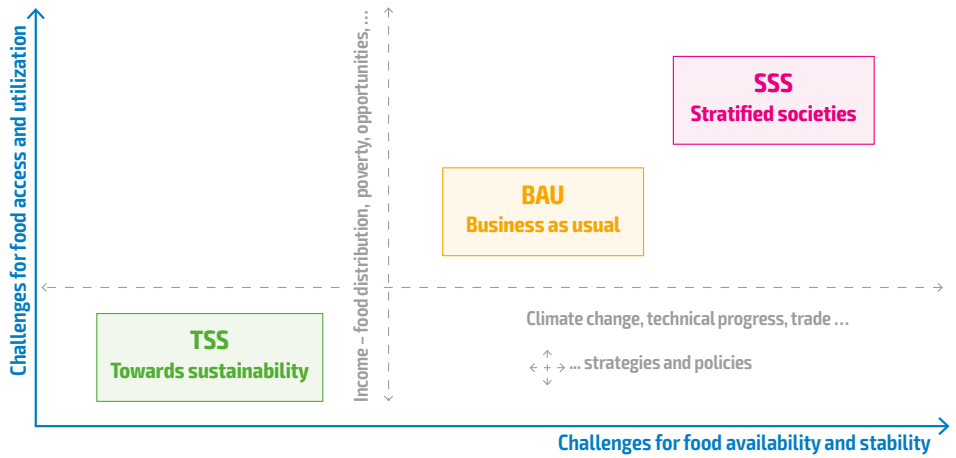
The analysis of the findings from the foresight exercise sheds some light on these questions and provides strategic options for decision-making by relevant actors and institutions.

FIGURE 1.3 GLOBAL URBAN AND RURAL POPULATIONS: HISTORICAL AND PROJECTED



Note: Projected figures from 2015 onward refer to the medium variant scenario.
Source: United Nations. 2015. *World Population Prospects: The 2015 Revision*. Department of Economic and Social Affairs, Population Division. New York, USA.

FIGURE 2.3 CHALLENGES TO FOOD AND AGRICULTURAL SYSTEMS AND KEY SCENARIO DRIVERS



Source: FAO Global Perspectives Studies.

3. MANAGING FOOD DEMAND AND CHANGING PEOPLE'S DIETARY PREFERENCES

What can be done to manage food demand and change people's dietary preferences?

KEY MESSAGES

1. **Managing consumer demand through awareness raising and proper regulations can help contain the expansion of agricultural sectors.** Food and non-food agricultural production is expected to rise because of population and income growth. However, the expansion of agricultural sectors can be significantly contained by, for instance, rasing consumer awareness on environmentally sustainable diets, regulating and discouraging food waste, enforcing more efficient food pricing and limiting the use of biofuels.

2. **Demand management through consumer awareness and education is also essential to reduce the "triple burden" of malnutrition.** Consumer awareness and education regarding the nutritional content of food and diet-related diseases are also critical to reduce the "triple burden" of malnutrition that is, undernourishment, micronutrient deficiencies, and overweight and obesity, that often exist within a single country or even community, and to achieve a shift towards generally healthier diets.

3. **Food prices should be "right".** Food prices should reflect the inherent nutritional value of food as well as the full range of costs associated with their production and consumption along the entire food value chain. This includes environmental costs such as biodiversity loss, land degradation, water depletion, GHG emissions, which are often not accounted for. This can help limit the growth of food demand and reduce food losses and waste, while contributing to the preservation of natural resources and the improvement of nutrition.[8] However, as higher food prices may hamper poor people's ability to buy food, targeted and efficient strategies are needed to raise their purchasing power.[9]

4. **Dietary patterns of high-income countries need balancing.** While moving towards sustainable food systems, neither restrained expansion of production nor increased food prices would substantially impinge on global food availability – including in low- and middle-income countries – if high-income countries were to consume less animal products, and food waste and loss were considerably reduced. Raising consumer awareness on this issue could be key. Balanced diets are critical for reducing all types of malnutrition, including undernourishment but also overweight and obesity, often causing non-communicable diseases.

[8] Economists have traditionally regarded unpaid environmental costs as "environmental externalities", which lead to a suboptimal economy-wide outcome. Achieving optimal results in the presence of externalities implies making sure that economic agents pay the correct price for their actions (Varian, 1992).

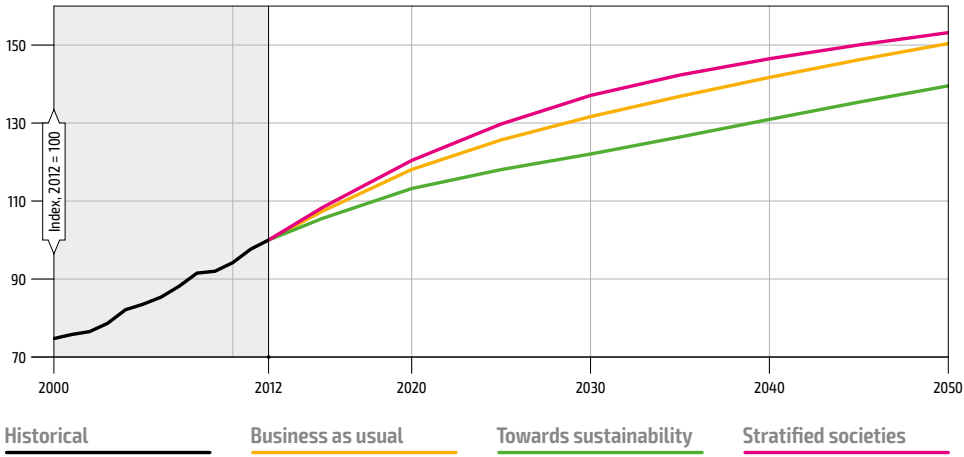
[9] Legitimate concerns regarding the purchasing power of poor people, as well as possible strategies to increase it, are addressed in the following section..

5. International trade may help exploit production potential and fill food deficits.
Sustainably expanding the supply of food in countries whose population is expected to increase significantly is essential to ensure adequate food availability. Trade has an important role to play here, and imports may well be needed to fill domestic deficits in case natural resource constraints are an issue. However, strong global and national institutions are needed to coordinate efforts across countries and prevent unfair competition against those countries that adopt more stringent environmental and social regulations.

Despite the fact that each scenario analysed in this report assumes the same demographic patterns, agricultural demand and the corresponding expansion of agricultural output required to satisfy that demand exhibit significantly different dynamics. While under the BAU and SSS scenarios global gross agricultural output from the base year to 2050 is expected to increase by about 50 percent and 54 percent respectively, from the base year to 2050, under the TSS scenario the expected increase is only 40 percent (Figure 4.2).

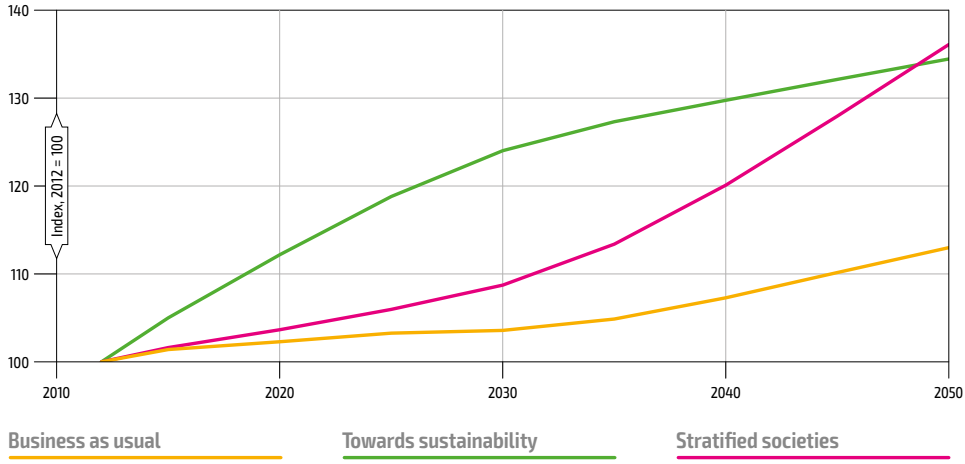
Food demand is highest under the SSS scenario, which largely explains the higher increase in agricultural output. It is boosted by a significantly larger increase in per capita income compared with the other scenarios – in almost all regions except SSA –

FIGURE 4.2 GROSS AGRICULTURAL OUTPUT AT BASE-YEAR PRICES



Note: Gross agricultural output is measured as the sum of all primary agricultural commodities as defined in Annex III, Table A 3.3 of the report, multiplied by their corresponding base-year prices. Note that this excludes natural rubber but includes both feed and animal products. On the other hand, fish is excluded to maintain comparability of this indicator with previous FAO studies. Details for specific regions are given in Annex III, Table A 3.4 of the report.
Source: FAO Global Perspectives Studies, based on simulations with the FAO GAPS model.

FIGURE 4.3 PROJECTED AGRICULTURAL PRODUCER PRICE INDEX



Note: This index is calculated by dividing the value of a set of agricultural commodities at current-year prices by the value of the same set at base year (2012) prices (Paasche agricultural producer price index).
Source: FAO Global Perspectives Studies, based on simulations with the FAO GAPS model.

as well as by persistent consumer preferences for resource-intensive food items and unabated food loss and waste, particularly in HIC.

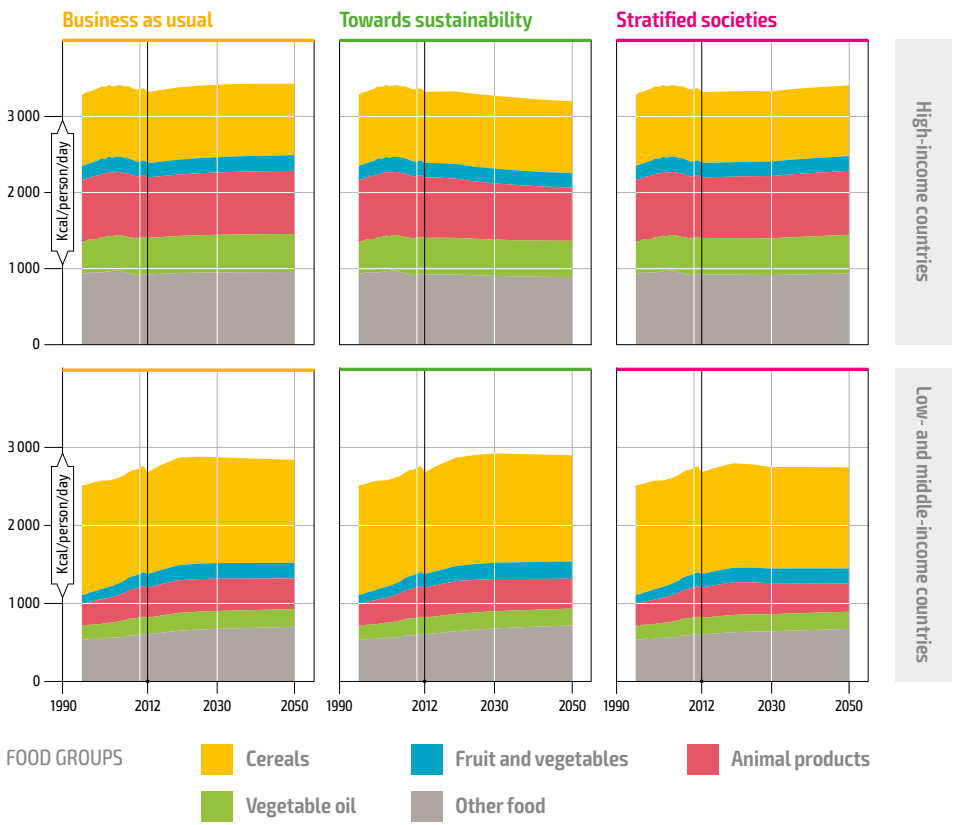
The TSS scenario is more sustainable, as a set of concurrent changes in food systems helps reduce pressure on agricultural sectors. These include:

- early and significant agricultural price increases (Figure 4.3) due to more limited supply related to environmental constraints that help lower the demand for agricultural goods;
- changing consumer preferences, particularly in HIC, leading to a reduction in the per capita consumption of animal products (Figure 4.5);
- reduced food loss and waste at all levels of the food chain;
- reduced pressure from the demand for non-food agricultural products, including animal feed.

It is worth emphasizing that despite reduced agricultural output, satisfactory food availability is ensured in TSS, particularly in LMIC, where each person enjoys more food on average than in the other scenarios (Figure 4.5). This occurs as per capita income grows in many countries, some of which also opt for more balanced diets consisting of less animal products and more nutritious food such as fruits and vegetables – which on a path towards sustainability are likely to result in, *inter alia*, a reduction in the prevalence of obesity, overweight and associated

non-communicable diseases. Although relatively more limited, compared with the other two scenarios, the expansion of gross agricultural output under the more sustainable TSS scenario still almost satisfies domestic demand, so that agricultural trade represents only a limited fraction of production and consumption. However, in some instances the self-sufficiency ratio of certain LMIC regions falls below that of the BAU and SSS scenarios and the food and agriculture domestic deficit is compensated by international trade. This is the case for cereals in the Near East and North Africa (NNA) and South Asia (SAS), fruits and vegetables in SAS and sub-Saharan Africa (SSA),

FIGURE 4.5 DAILY ENERGY CONSUMPTION BY SOURCE AND SCENARIO



Notes: Data before 2012 refer to daily energy supply; after 2012, data refer to daily energy consumption. The food groups are detailed in Annex III, Table A 3.5 of the report.
Source: FAO Global Perspectives Studies, based on simulations with the FAO GAPS model.

and oilseeds in NNA and East Asia and the Pacific (EAP) (excluding China). Meanwhile, self-sufficiency ratios in other regions move in the opposite direction. The possibility for selected countries to balance out food deficits with imports promotes a more balanced use of natural resources, while helping to meet the demand for food.

These findings from the TSS scenario indicate that containing agricultural expansion to move agricultural sectors towards sustainability, while also increasing food availability, is possible, particularly in the case of LMIC. However, achieving such results rests on the assumption that a set of synergic strategic orientations will be undertaken, including:

- raising consumer awareness regarding healthy diets and food waste, particularly in HIC;
- making prices "right" by ensuring that they reflect all the costs associated with the production and consumption of agricultural products, including environmental costs, so that those costs are charged to resource users;
- reducing feed requirements, for example, through improved livestock management and avoiding excessive meat consumption;
- reducing the pressure from biofuels by implementing other forms of renewable energy;
- safeguarding the development potential of the agricultural sectors, particularly in LMIC, while facilitating the international trade in selected food items to compensate for domestic food deficits.

GUATEMALA
Fruit and vegetables market in Chichicastenango.
©FAO/Daniela Verona

4. SUSTAINABLY ADDRESSING THE SCARCITY AND REDUCED QUALITY OF LAND AND WATER RESOURCES

How to address the scarcity and reduced quality of land and water resources in a sustainable manner?

KEY MESSAGES[10]

1. **Sustainable agricultural intensification is key to saving land.** Due to increasing agricultural production and unsustainable practices, the demand for land might exceed the available reserves of very suitable and unprotected land for rainfed crops, as is already the case in specific regions such as the Near East and North Africa, or in selected countries in East Asia and the Pacific. This could entail environmental problems or additional production costs from using lower-quality land and/or building additional infrastructures. As shown by the findings of this report, the sustainable intensification of agricultural sectors can potentially lower the expansion of demand for land while maintaining soil quality.
2. **Avoiding further land degradation and encouraging land rehabilitation helps tackle land constraints.** Although limited, available information on land degradation suggests that current agricultural practices lead to productivity losses that require an increase in the input intensity. Efforts to rehabilitate degraded land and practices that limit degradation are required to maintain the resource base and reduce the use of inputs.
3. **Using water more efficiently is increasingly becoming a must.** Many countries already exploit their water resources at unsustainable rates, thereby jeopardizing the potential for future production. Climate change and population growth may exacerbate water scarcity. Under these conditions, increasing the efficiency of water use is becoming increasingly crucial.
4. **Trading off agricultural yields and sustainability.** The adoption of sustainable agricultural practices might require forgoing certain yield increases, particularly when such increases lead to the overuse of water resources, a reduction in soil fertility, the loss of biodiversity and higher GHG emissions. However, some recovery in yield growth could materialize in the long run, due to a restored natural resource base, or as the result of an improvement in farmers' expertise.
5. **All the above does not come for free: significant investments are needed.** To ensure that sufficient land and water resources are available to meet total demand from agriculture, significant investments are required in the research and development of sustainable technologies and practices, infrastructure and human capital.

[10] This section draws heavily on work carried out by FAO and its partners to investigate and promote sustainable agricultural practices, as documented in: *Building a common vision for sustainable food and agriculture. Principles and approaches* (FAO, 2014); *Voluntary guidelines for sustainable soil management* (FAO, 2017e); *Save and Grow – A policy maker's guide to the sustainable intensification of smallholder crop production* (FAO, 2011c) and related follow-up publications; *Voluntary guidelines on the responsible governance of tenure of land, fisheries and forestry in the context of national food security* (FAO, 2012); *Strategic work of FAO for sustainable food and agriculture* (FAO, 2017f).

A second question regarding the future of food and agricultural systems is whether the increase in gross agricultural output required to ensure adequate food availability can occur within the boundaries of available natural resources, and specifically land and water. Limited information exists regarding the economic costs of expanding arable land in different countries and contexts. However, it is generally recognized that the expansion of arable land, particularly in regions where very suitable land for agriculture is scarce, may have environmental implications that jeopardize ecosystems, protected areas, forests and biodiversity. In addition, expanding agriculture into less suitable land may be technically possible in many instances, but would likely imply lower yields, require the use of additional inputs or necessitate additional investments in infrastructure that would increase production costs.

The three scenarios analysed in this report portray significantly different pictures regarding additional land requirements. Under the BAU and SSS scenarios, land requirements increase from an initial 1 567 million hectares in 2012 to 1 732 million hectares (BAU) and 1 892 million hectares (SSS) by 2050, representing increases of 11 and 21 percent, respectively (Figure 4.13).

Under both the BAU and the SSS scenario, the increase in land requirements is attributed to the above-mentioned expansion of agricultural production, and the limited or lacking crop intensification, which is the average number of crop harvests obtainable in a given period on the very same plot. This applies particularly in SSA and NNA (Figure 4.16). These both imply minimal or utterly ineffective efforts to increase land productivity in a given period. Regarding SSA in particular, all three scenarios suggest that productivity remains well below that of other regions under all three scenarios. This is because, due to the substantially lower historical levels, any projected growth rates of crop yields are not sufficient to lift, for example, cereal or fruit and vegetable productivity into ranges seen for other regions. Indeed, under the BAU and SSS scenarios, crop intensification accounts for only 16 and 10 percent of additional agricultural production, respectively, while the bulk of the increase in production is attributable to increases in yields and the amount of arable land, particularly in SSS. In regions where the availability of land is more limited, and intensification is not restrained by the length of the growing period (such as parts of the Mediterranean region and EAP), yield growth and intensification play a greater role in expanding agricultural production than increases in arable land.

The opposite occurs under the TSS scenario, where almost no additional arable land is required as compared

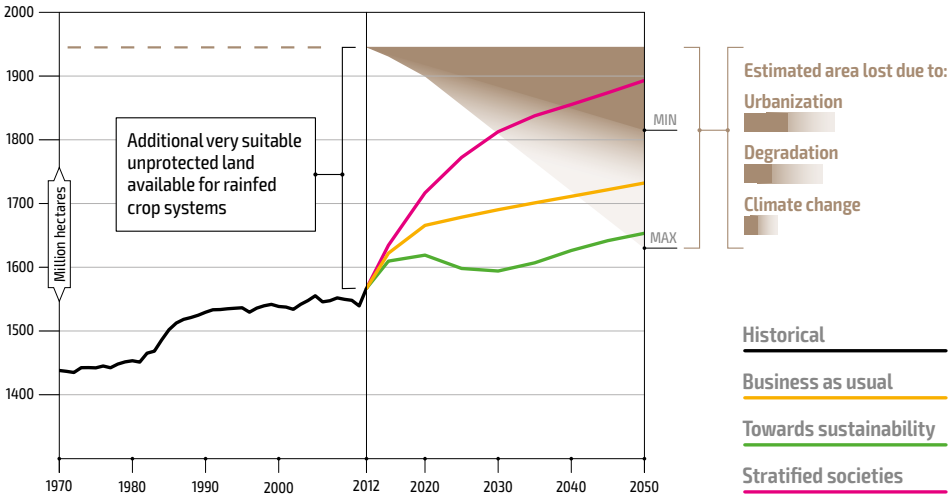
with 2012, while agricultural growth results mainly from crop intensification and moderate yield increases.

It is important to note that achieving sustainable agricultural intensification requires a substantial paradigm shift to reconcile growing human needs with the need to strengthen the resilience and sustainability of landscapes and the biosphere (Rockström *et al.*, 2017). This calls for bold changes in the technological aspects of production systems to improve their ecological efficiency.

Long-term strategies, policies and programmes are required to promote, for example:

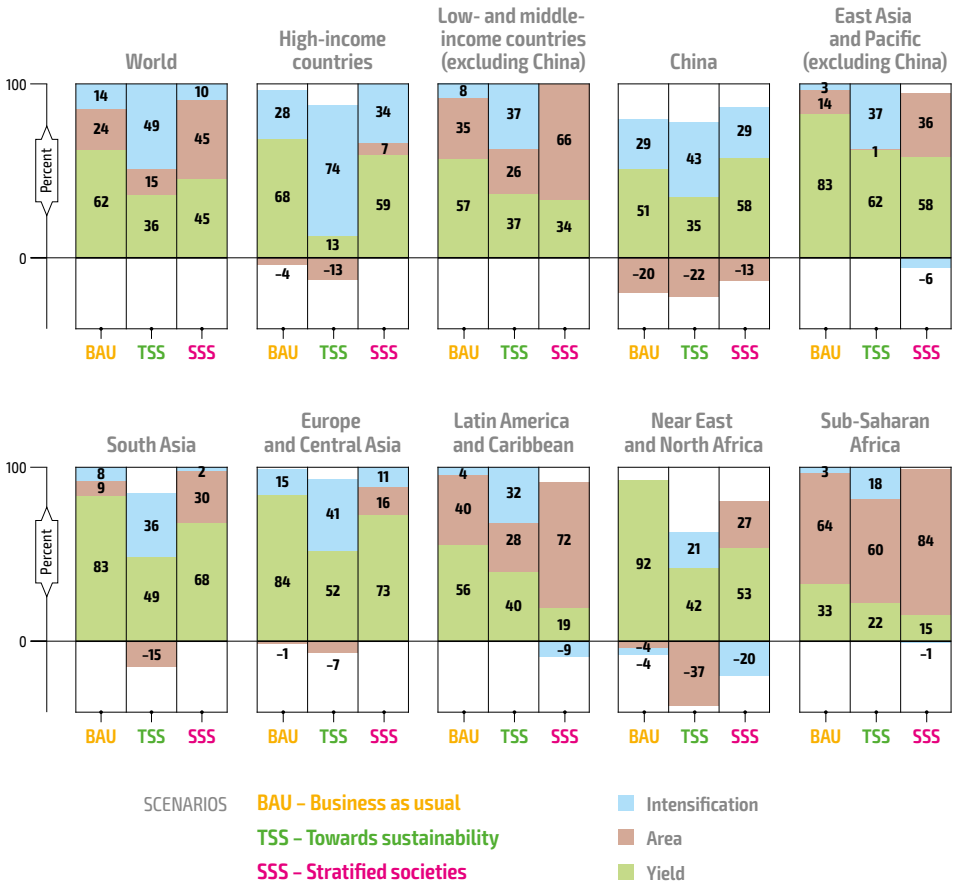
- improved resource linkages and enhanced nutrient flows in integrated farming systems, such as rice–fish farming and other crop–livestock systems;
- higher-quality feed and balanced animal diets;
- low-input and precision agriculture;
- innovative land and water conservation techniques, improved biodiversity preservation

FIGURE 4.13 **GLOBAL ARABLE LAND REQUIREMENTS BY SCENARIO AND ESTIMATED LOSS OF AGRICULTURAL AREAS TO URBANIZATION, DEGRADATION AND CLIMATE CHANGE**



Note: "Additional very suitable and unprotected land" represents the base-year amount of land available and not currently in use in the highest suitability class for rainfed crops, as in FAO-IIASA GAEZ v4 (see Box 7 and Section 3.10 of the report). Adding this land to the arable land in use in 2012 (irrigated and rainfed) provides an estimate of the maximum potentially available very suitable unprotected agricultural land (dashed line), given 2012 irrigation conditions. Expanding cropland beyond that limit requires progressively increasing investments. The faded wedge indicates the range of potential land loss (dark brown: minimum, light brown: maximum). Land loss due to urbanization (in the range of 1.6 million–3.3 million hectares per year) and degradation (in the range of 1.0 million–2.9 million hectares per year) are taken from Lambin and Meyfroidt (2011). Loss due to climate change (in the range of 0.5 million–1.4 million hectares per year) refer to the RCP scenarios – 4.5 (min) and 8.5 (max) – and are based on the FAO-IIASA GAEZ v4.
Sources: FAO Global Perspectives Studies, based on simulations with the FAO GAPS model and FAOSTAT (various years).

FIGURE 4.16 **SOURCES OF GROWTH IN CROP PRODUCTION IN 2050, BY REGION AND SCENARIO**



Note: The contributions of changes in yield, arable area and intensification to changes in crop production were calculated by relating the change in one component to the total change in crop production, while keeping the other two components constant. As the three relative contributions together do not account for the full change in crop production, the residual change was attributed proportionally to each of the components, to obtain a fully consistent breakdown.
Source: FAO Global Perspectives Studies, based on simulations with the FAO GAPS model.

technologies, enhanced production technologies (such as agroforestry, organic agriculture, agroecology) and integrated pest management;
- the use of information and communication technologies to accelerate the spread and adoption of innovations.

Shifting the currently prevailing production paradigm carries some costs, with two particularly important implications.

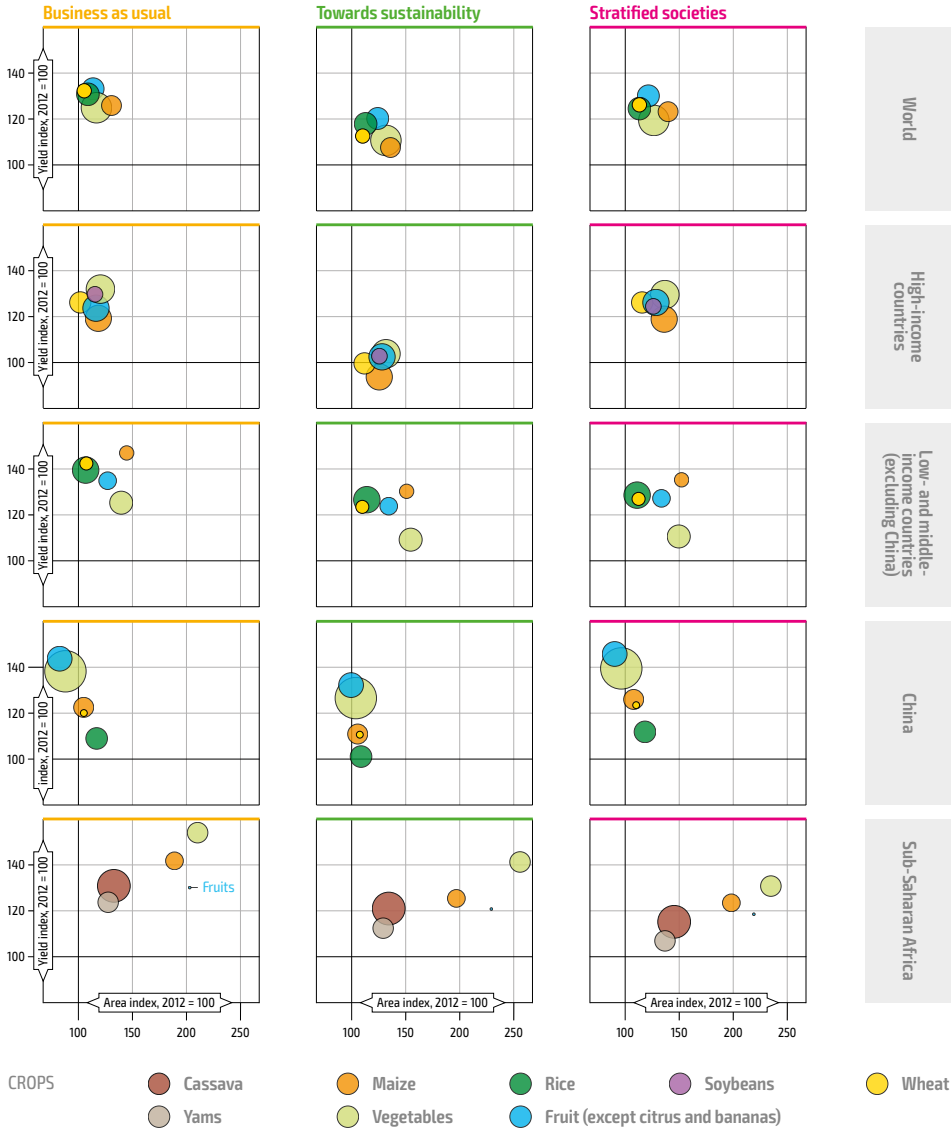
First, some productivity gains would have to be given up, particularly in the short to medium term (Figure 4.11), as a consequence of the adoption of more environmentally-friendly techniques. Second, such a paradigm shift requires massively investing in several domains, including in research and development to produce effective and robust results for sustainable agriculture and food production, infrastructure-building, natural resources rehabilitation, human capital and expertise. and the dissemination thereof. All agents in food and agricultural systems would thus need to acquire the necessary know-how, while institutions will need to set up and enforce rules and regulations.

The importance of these actions is widely documented in all FAO work aimed at investigating and promoting sustainable agricultural practices. These investments require additional public funds, which would have to be recovered through general taxes. However, private investments would also be required to replace obsolete capital while transitioning towards sustainable agriculture and food systems. The additional investment will need to be recovered, thus possibly placing upward pressure on food and agricultural prices at least in the initial phases of this transition, as highlighted above under the TSS scenario.

Underpricing food may continue to encourage the overuse of natural resources, overconsumption and food waste, particularly by affluent people, with detrimental effects on the pace of progress towards sustainability. However, concerns that higher prices may hamper the capacity of poorer segments of the population and particularly of those who already suffer from hunger or severe malnutrition to procure sufficient food of satisfactory quality, are legitimate and need to be considered carefully. Poverty is among the main causes of environmental degradation in low-income countries, and sustainability cannot exist without equitability. While adequate social protection mechanisms can certainly provide immediate help for the extreme poor to overcome liquidity constraints and procuring food, programmes such as the UN Poverty–Environment Initiative[11] and projects that promote innovation

[11] See: www.unpei.org

FIGURE 4.11 **YIELDS AND HARVESTED AREAS FOR THE FIVE MAJOR CROPS, BY REGION: CHANGES 2012–2050**



Note: The figures show changes in harvested area (x-axis) and yield (y-axis) for the five most important crops in each region in 2050 relative to the base year. Crops are ranked on the basis of their production value, calculated as the physical output at the base year multiplied by base-year prices in USD. Circle sizes are proportional to the share of production value in the base year.
Source: FAO Global Perspectives Studies, based on simulations with the FAO GAPS model.

in family farming need to be strengthened, as they not only help reduce poverty but also contribute to preserving ecosystems and promoting environmentally sustainable economic growth.[12]

[12] An example is the FAO project "Farmer Innovation and New Technology Options for Food Production, Income Generation and Combating Desertification in Kenya" (see www.fao.org/in-action/promoting-farmer-innovation-and-ffs-in-kenya/en).

YEMEN
Water use for rural livelihoods.
©FAO/Soliman Ahmed

5. ADDRESSING POVERTY AND INEQUALITY TO ACHIEVE FOOD SECURITY AND NUTRITION GOALS

Will poverty, inequality and unemployment continue to constrain food access and hamper the achievement of food security and nutrition goals?

KEY MESSAGES

1. **Defeating undernourishment requires reducing poverty and inequalities.** The findings of this report show that much more than "business as usual" will be required to defeat undernourishment. A bold move towards a more equitable income distribution – to be achieved through diverse strategic options, including by ensuring a more equitable access to assets for the poor people, with a focus on family farmers – is the most effective way to ensure that the reduction in undernourishment seen in the past years continues uninterrupted in the future.

2. **Environmental sustainability and food security can go hand in hand.** While moving food and agricultural systems towards sustainability drives food prices up and restrains global agricultural output, the per capita food availability in low- and middle-income countries can substantially expand if a more equitable distribution of income within and across countries is pursued.

3. **A more equitable income distribution allows for improved and healthier diets.** The consumption of healthy items, such as fruits and vegetables is likely to increase if income is more equally distributed within and across countries, and particularly low- and middle-income countries. Overall, cereals would remain the most important source of calories.

4. **Moving towards sustainability may help increase farm profitability and/or agricultural employment.** Sustainable agricultural practices can raise farm profitability and/or labour opportunities in agricultural sectors. This would contribute to a more equitable distribution of income, which may in turn be critical to improve food security and nutrition.

5. **Food and agricultural sectors are key, but no longer enough on their own to ensure equitable access to food.** Agricultural sectors continue to be important for employment and income generation in low- and middle-income countries. However, they alone no longer provide enough jobs or income-earning opportunities. On the one hand agriculture and family farming in particular, must be more firmly linked to the broader rural and urban economy. This can be done by developing agro-industries and setting up infrastructure to connect rural areas, small cities and towns. On the other hand, strong institutions supported by efficient fiscal systems, are needed to ensure economy-wide income-earning opportunities, effective social protection, competitive and equitable domestic and international markets for inputs and outputs.

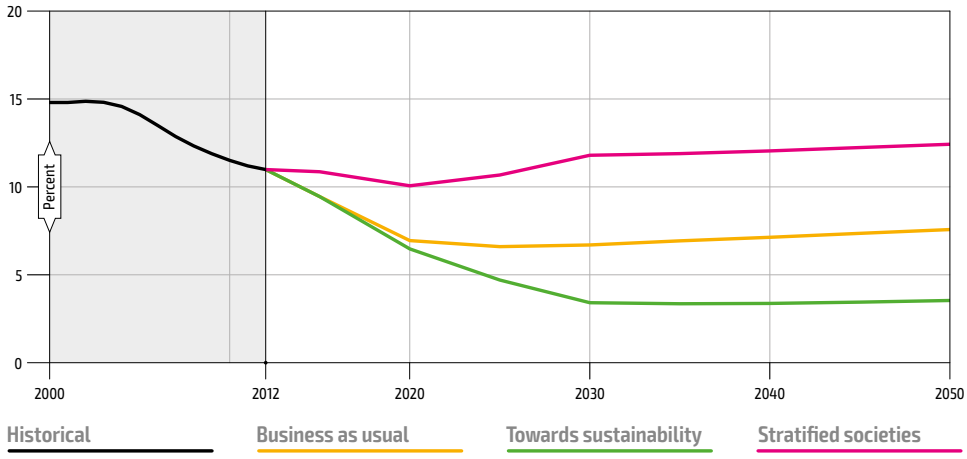
A third question regarding the future of food and agricultural systems is whether they will become more equitable, with access to sufficient and nutritious food for all is increasingly ensured, orif they will move in the opposite direction. This question becomes even more compelling in light of prospective agricultural prices increase particularly under the TSS scenario, which, other things being equal, would make access to food more onerous. The ensuing question is whether trade-offs would emerge between economic, environmental and social sustainability – that is, whether attempting to improve the ecological performance of food systems would imply giving up other desirable objectives, such as universal and permanent food security and improved nutrition.

It is generally recognized that without reducing inequalities in income, access to resources and earning opportunities, it will not be possible to eliminate hunger and extreme poverty (World Bank, 2016). The scenario analysis presented in this report provides insights on the conditions necessary for undernourishment to drop significantly and nutrition to improve, and those which would lead to a deterioration on both fronts. Reading across the scenarios also highlights the importance for food and agricultural sectors to contribute to increasing access to food through equitable access to land and water, credit facilities, improved information, opportunities to increase know-how, job creation, decent wages and diversified earning opportunities for rural people.

Under the BAU scenario, almost 7 percent of the world's population is still undernourished in 2030, compared with 11 percent in 2012 (Figure 4.8). This result confirms the trends already identified in the report *Achieving zero hunger* (FAO, IFAD and WFP, 2015b). Under the BAU scenario, the picture looks even worse in 2050, with undernourishment jumping to almost 8 percent. The limited drop in the percentage of undernourished people in 2050 compared with 2012 leaves the number of undernourished almost unchanged up to 2050 (Figure 4.9). An even worse situation unfolds under the SSS scenario, where the PoU climbs to more than 12 percent by 2050, leaving almost one billion people undernourished.

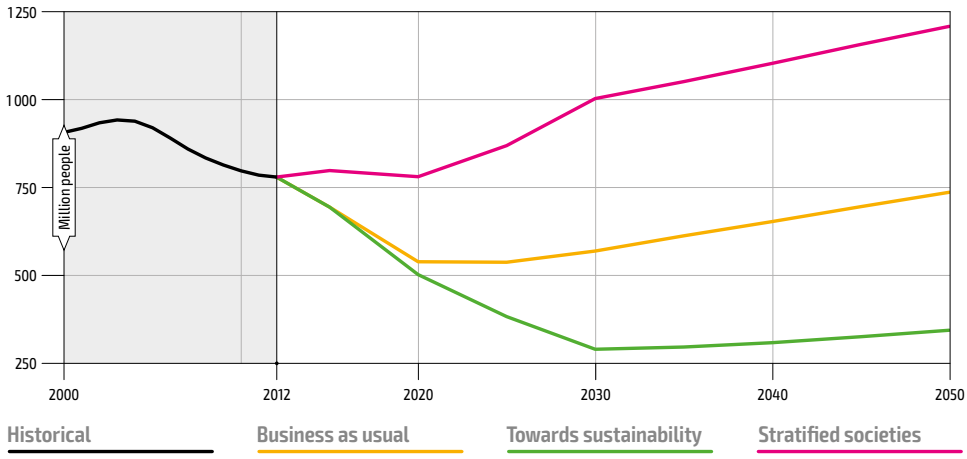
The TSS scenario portrays a completely different picture: the percentage of undernourished people drops to well below 4 percent of the world population, and their absolute number decreases to fewer than 400 million. Following this path towards sustainability, the average apparent per capita dietary composition also moves towards less meat consumption, specifically in HIC (compared with the other scenarios) which is associated with relatively higher consumption of fruits and vegetables in LMIC compared with HIC (see Figure 4.6).

FIGURE 4.8 PREVALENCE OF UNDERNOURISHMENT: GLOBAL, HISTORICAL AND PROJECTED



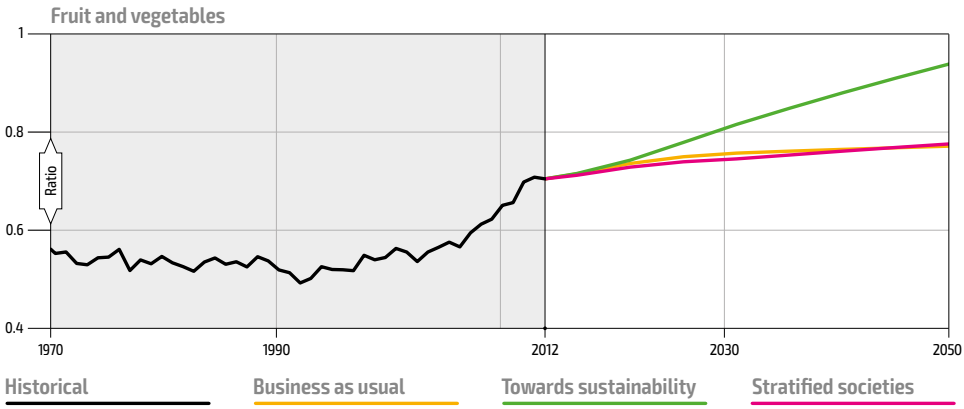
Source: FAO Global Perspectives Studies, based on simulations with the FAO GAPS model.

FIGURE 4.9 NUMBER OF UNDERNOURISHED PEOPLE: GLOBAL, HISTORICAL AND PROJECTED



Sources: FAO Global Perspectives Studies, based on simulations with the FAO GAPS model. Historical data based on: FAO, IFAD, UNICEF, WFP and WHO. 2017. ***The State of Food Security and Nutrition in the World 2017: Building resilience for peace and food security***. Rome, FAO; and United Nations. 2015. ***World Population Prospects: The 2015 Revision***. Department of Economic and Social Affairs, Population Division. New York, USA.

FIGURE 4.6 **PER CAPITA KILOCALORIE CONSUMPTION FROM FRUIT AND VEGETABLES IN LOW- AND MIDDLE-INCOME COUNTRIES (EXCLUDING CHINA) AS A SHARE OF THAT IN HIGH-INCOME COUNTRIES**



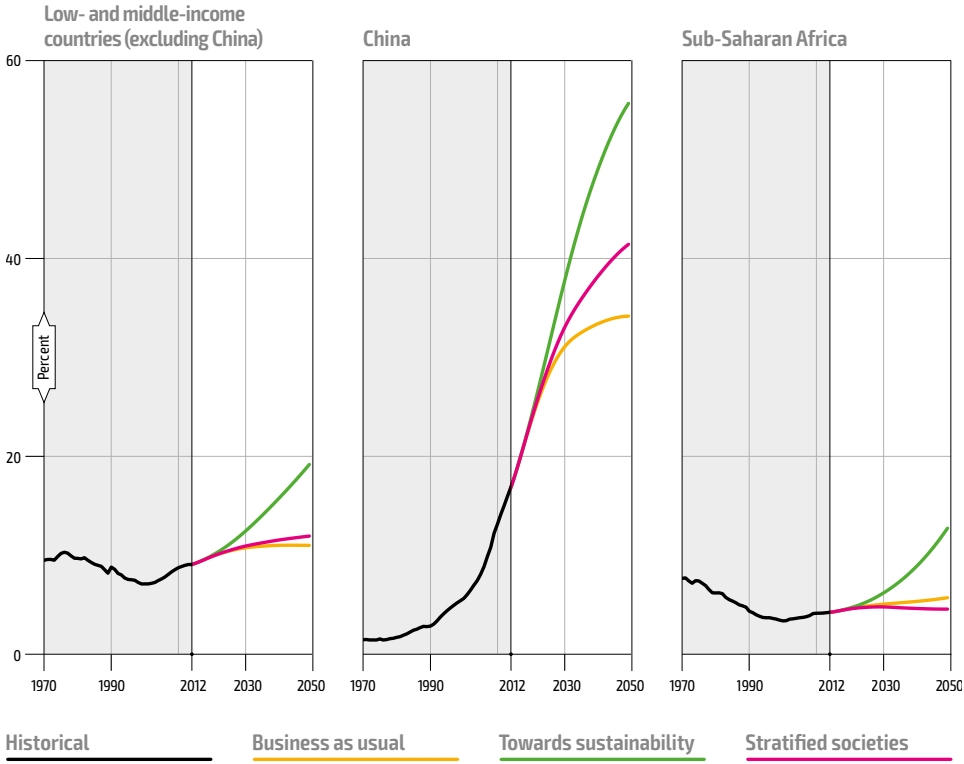
Notes: The grey, vertical line represents the base year 2012. A ratio higher/lower than 1 suggests that the per capita kilocalorie intake from fruits and vegetables in LMIC is higher/lower than in HIC, whereas a ratio closer to 1 suggests that the dietary patterns of LMIC and HIC converge. The data before 2012 refer to per capita kilocalorie supply. The data for 2012 and thereafter refer to per capita kilocalorie consumption. Food groups are detailed in Annex III, Table A 3.5 of the report.
Sources: FAO Global Perspectives Studies, based on simulations with the FAO GAPS model and FAOSTAT (various years).

It follows that a more sustainable pathway, characterized by reduced food availability and agricultural price increases, would not have a negative effect upon the performance of food systems in terms of food security and nutrition. In other words, there are no apparent trade-offs between environmental and social sustainability. There are two complementary reasons why the TSS scenario outperforms the other two in terms of food security and nutrition:

- One reason is the increased purchasing power in LMIC, resulting from a more equitable income distribution across countries (Figure 3.6). TSS is the only scenario that shows a positive trend towards per capita income convergence between LMIC and HIC,[13] allowing consumers in LMIC to buy more food. As a result, people in LMIC take in more per capita kilocalories than under the BAU scenario, and almost the same amount as under the SSS scenario. The effect is particularly strong in SSA, where the per capita income is markedly higher under the TSS scenario than under the other two scenarios.

[13] Under BAU and SSS, LMIC and SSA in particular, are far from catching up with HIC in terms of per capita income, as the share of their per capita income in 2050 is still about 10 percent of HIC. China is an exception as in all scenarios it shows a positive trend towards convergence with HIC, as has been observed since 1980.

FIGURE 3.6 **PER CAPITA GROSS DOMESTIC PRODUCT IN LOW- AND MIDDLE-INCOME COUNTRIES AND CHINA, AS PERCENTAGE OF THAT IN HIGH-INCOME COUNTRIES**



Sources: FAO Global Perspectives Studies, based on data from the United Nations System of National Accounts (UN, 2016), for the 1990–2012 period; and the Shared Socio-economic Pathways (SSP) database version 1.1, OECD projections of gross domestic product (SSP database, 2016) for the 2013–2050 period.

- The other reason is the more equitable food distribution within countries, achieved by means of a more equitable distribution of income across the different layers of societies, particularly in LMIC.

Income is more equitably distributed in TSS as compared with the BAU scenario, under the assumption that investments are oriented towards "pro-poor" growth. This implies that earning opportunities are available across all layers of society, basic services are universally accessible, and effective income redistribution mechanisms are at work. Under the TSS scenario, unskilled labour wages in LMIC are projected to be comparatively higher than in under the BAU scenario including in agriculture; in many instances,

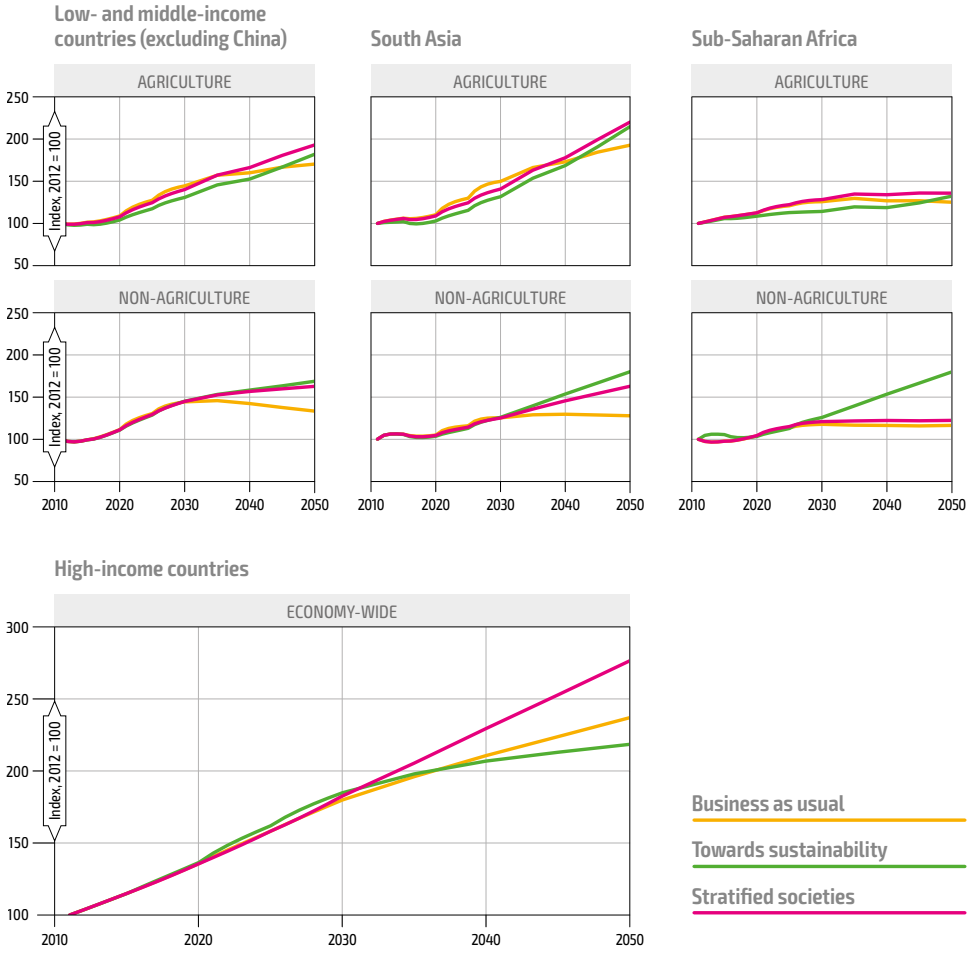
they are also higher than under the SSS scenario (Figure 4.4, green lines).

Moving food and agricultural systems towards sustainability may result in higher wages in agriculture or in the creation of additional employment – or both, depending on the system. For example, "conservation agriculture" could increase labour productivity, particularly where the supply of rural labour is relatively scarce, although in many instances, this would entail a more intensified use of herbicides and fungicides (Derpsch *et al.*, 2010; Kassam *et al.*, 2009; FAO, 2001); this type of agriculture must be adapted to local conditions (Pannel, Llewellyn and Corbeels, 2014). Meanwhile, "organic agriculture" practices can help to absorb labour, particularly where rural labour supply is abundant (Nemes, 2009; Herren *et al.*, 2012; Muller *et al.*, 2017).

Improving the income distribution within and across countries is imperative if food security and nutrition objectives are to be achieved while also ensuring the environmental sustainability of food systems. This is challenging in a world where inequalities remain pervasive, between rural and urban areas, regions, ethnic groups, and men and women. Moreover, the evidence indicates that "the rich are getting richer" (World Bank, 2016), while the rising trends in undernourishment highlighted in *The State of Food Security and Nutrition in the World 2018* (FAO, IFAD, UNICEF, WFP and WHO, 2018) are a clear indication that the poor may be becoming poorer. In this context, LMIC look highly unlikely to catch up with HIC for several decades (FAO, 2017a). However, agricultural sectors and food systems in general have a fundamental role to play in addressing this challenge, and some strategic options are available to promote equitable and pro-poor growth, including, for example:

- stepping up public spending on research and development and enabling a better environment for private research into innovative sustainable agricultural technologies, particularly those suitable to family farmers;
- ensuring family farmers' access to innovative technologies through measures such as specific credit lines, which may help shoulder the initial adoption costs, incentives and advisory services to motivate and support the learning phases, and other institutional arrangements, such as the creation of communities of practice to share information, exploit economies of scale, procure equipment in bulk at fair prices, or participate in dedicated insurance schemes for risk management;
- improving coordination along value chains and ensuring that the weaker segments in the chain reap the benefits of integrating agricultural sectors into wider markets;
- protecting asset ownership and control, including through effective

FIGURE 4.4 **AVERAGE WAGES FOR UNSKILLED LABOUR IN AGRICULTURAL AND NON-AGRICULTURAL SECTORS**



Note: No distinction is made between agricultural and non-agricultural wages in the case of HIC; in these countries, the market for unskilled labour is assumed to exhibit very limited segmentation between agriculture and non-agriculture sectors.
Source: FAO Global Perspectives Studies, based on ENVISAGE model results.

institutional arrangements and transparent land markets, particularly for those segments of the population driven out of agriculture by economic transformations and urbanization, with a view to preventing the dispossession of essential capital;
- building and/or reinforcing institutions that ensure the competitiveness of markets for agricultural inputs and outputs, prevent undue concentration, regulate oligopolies and oligopsonies, and prevent rent seeking behaviour that diverts income away from farmers;
- promoting investment in agricultural sectors only if it is compliant with the principles for responsible investment in agriculture and food systems, to ensure that it contributes to sustainable and inclusive economic development, the eradication of hunger and poverty, access to safe and nutritious food, equality and empowerment at all levels, resilience and the reduction of disaster risks (CFS, 2014).

Despite its key role, it is increasingly clear that agriculture alone is no longer enough to significantly improve equity and support pro-poor growth. The ongoing wider process of economic transformation has led in many instances to fewer people being engaged in agriculture, and available analysis signals that this trend may continue. This may lead to further urbanization and international migration, particularly if decently remunerated jobs and alternative earning opportunities are not generated in rural areas, off-farm and outside of agriculture. Permanently reducing poverty requires actions that cut across rural and urban areas, and, by and large, across countries and regions. This would require, for example:

- providing broad and gender-balanced access to good quality health services, sanitation and education, as well as to professional training and retraining, especially for marginal farmers prone to leaving agriculture, to allow people to benefit from technical progress and economic transformations, while reducing poverty;
- promoting economic diversification into rural non-farm income-generating activities by developing industrial (sector-specific) policies, protecting infant industries and implementing measures to favour private businesses, particularly small- and medium-sized enterprises and create jobs (FAO, 2017g);
- promoting the development of agro-industries and setting up the territorial infrastructure needed to interconnect rural areas, small cities and towns, so that rural populations can benefit from structural transformation and urbanization;
- supporting economy-wide job creation through the promotion of equitable innovative processes, and ensuring decent job remuneration

and working conditions through the use of enforceable laws and regulations;
- implementing adequate social protection mechanisms to provide immediate relief for undernourished, food-insecure and extremely poor people and help overcome households' liquidity constraints, thus enabling individuals and communities to engage in more profitable but riskier income- and employment-generating activities (FAO, IFAD and WFP, 2015b);
- increasing the savings and investment potential of those without it, especially the poor through, for example, inclusive financing;
- facilitating the access to production factors such as land, water, credit, technical assistance and infrastructure, among others, with a focus on the poorest people.

All these measures require appropriate funding from both public and private sources. Official development assistance (ODA) and foreign direct investment (FDI), as well as other forms of funding that are increasingly available through various partnerships, may be required to support transformative processes that lead economic systems towards more sustainability, particularly in low-income countries (FAO, 2017a). However, significant additional funding may be generated by improving international and national governance and reinforcing institutions at all levels, including:

- setting up more equitable and effective fiscal systems to exploit the "fiscal space" that many countries, including some in the LMIC group, possess to fund public policies and orient development processes towards equitability and sustainability;
- significantly reducing illicit financial outflows,[14] which probably exceed ODA and FDI and strip resources from LMIC that could otherwise be used to finance much-needed public services and development policies (OECD, 2014). As illicit financial flows largely affect SSA (AfDB, 2013) (the region most prone to hunger) and such flows affect food and agricultural sectors as well (UNECA, 2014), tackling them may not only benefit public funds and citizens' incomes, but also have immediate and direct impacts on agricultural development and food security.

Given these considerations, it appears that achieving an equitable income distribution across and within countries – which would contribute considerably towards SDG2 (ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture) – requires full political commitment, innovative thinking and drastic changes to the

[14] See the SDG target 16.4: "By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime" and indicator 16.4.1: "Total value of inward and outward illicit financial flows (in current United States dollars)."

structure and relationship between labour and capital, agriculture and non-agricultural sectors, and LMIC and HIC.

A final remark regarding undernourishment: even under the TSS scenario, which is based on a decisively more equitable income distribution than the other scenarios, a combination of factors including population growth, price increases and climate change – albeit moderate – result in a rebound in the number of undernourished people after 2030. This suggests that progressive commitments may be required to not only achieve, but also maintain food security achievements in the long run.

TEXAS, USA
Homeless feeding.
©FlickrCC/Louis Tanner

6. TACKLING THE NEXUS BETWEEN CLIMATE CHANGE, AGRICULTURAL SECTORS AND LIVELIHOODS

How will climate change affect agriculture and rural livelihoods, and can agriculture help reduce GHG emissions?

KEY MESSAGES

1. **Climate change will incrementally affect all of the agricultural sectors.** Climate change already has negative effects on crop yields, livestock production and fisheries, particularly in low- and middle- income countries. Such impacts are likely to become even stronger later in this century.

2. **If left unaddressed, climate change will exacerbate poverty and inequalities.** Unaddressed climate change, which is associated, *inter alia*, with unsustainable agricultural practices, is likely to lead to more land and water use, disproportionately affecting poor people and exacerbating inequalities within and between countries. This carries negative implications for both food availability and food access.

3. **Climate change impacts go well beyond crop yields.** Climate change also affects soil quality, fish habitats and stocks, the biodiversity of landscapes, and the epidemiology and antimicrobial resistance of pests and diseases. There are great uncertainties about the combined effects of these impacts.

4. **Agricultural sectors can only reduce their GHG emissions through more investment.** Agricultural sectors can adapt to climate change and lower their GHG emissions while producing enough food for all. However, for this to be possible, substantial investments must be made to develop and implement more resource-saving and climate-friendly technologies.

5. **Efforts in agricultural sectors are not enough – drastic economy-wide GHG reductions are needed.** Although agricultural sectors have a significant potential for climate change mitigation through the adoption of better practices such as land conservation, increasing livestock efficiency, afforestation and reforestation, efforts in agriculture alone are not enough. Boosting energy-use efficiency and reducing GHG emissions per unit of energy must happen on an economy-wide basis.

A fourth concern regarding the future of food and agricultural systems is whether the sector – which will be increasingly affected by climate change – can substantially contribute to reducing global GHG emissions while producing enough food for all.

Agricultural sectors will be affected by climate change to varying degrees depending on the economy-wide amount of GHGs emitted in the coming decades. Existing knowledge of the relationships between climate change and agricultural performance is relatively limited. However, it is well known that climate change will affect crop yields as well as other ecological and social aspects, including biodiversity, soil quality, animal and plant resilience to diseases, and poverty and inequalities across and within countries. These factors could trigger migration flows and conflicts, with negative consequences of an unforeseeable magnitude for the well-being of billions of people (IPCC, 2014a).

Under the BAU scenario, climate change will negatively affect crop yields worldwide due to growing GHG emissions. The same holds true for the SSS scenario, where GHG emissions expand as economic systems grow. Meanwhile, GHG emissions decrease under the TSS scenario as a result of substantial investments that bring about more sustainable production and consumption patterns and ensure that the impact of climate change on crop yields is less severe than under the other scenarios (Figure 3.9).

It is well recognized that agricultural sectors are not only affected by climate change, to which they need to adapt; they also contribute substantially to it. Under the BAU and SSS scenarios, for example, GHG emissions from agricultural sectors increase by 24 and 54 percent, respectively, while the TSS scenario sees a substantial reduction of 39 percent in emissions (Figure 4.17).

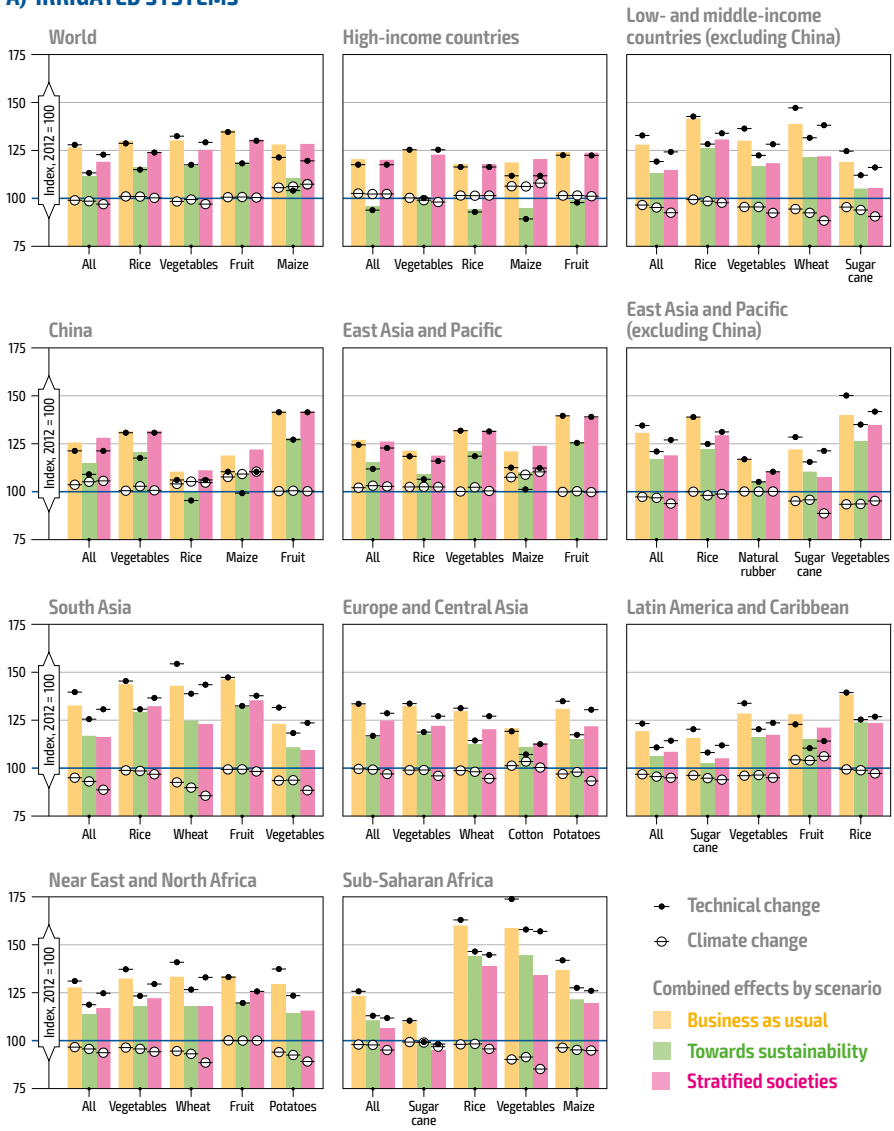
The notable reduction in GHG emissions by agricultural sectors under the TSS scenario is the joint result of three concurring factors:

- a reduced expansion in gross agricultural output compared with the other scenarios;
- a different composition of agricultural output, with a more limited expansion in livestock, and particularly of large and small ruminants, which significantly contribute to GHG emissions;
- efficiency gains in both crop and animal production processes as a result of reducing land and input use per unit of output.

The first two aspects pertain to changes in consumer habits and preferences, as discussed above. The third aspect relates to the way production processes are organized and managed.

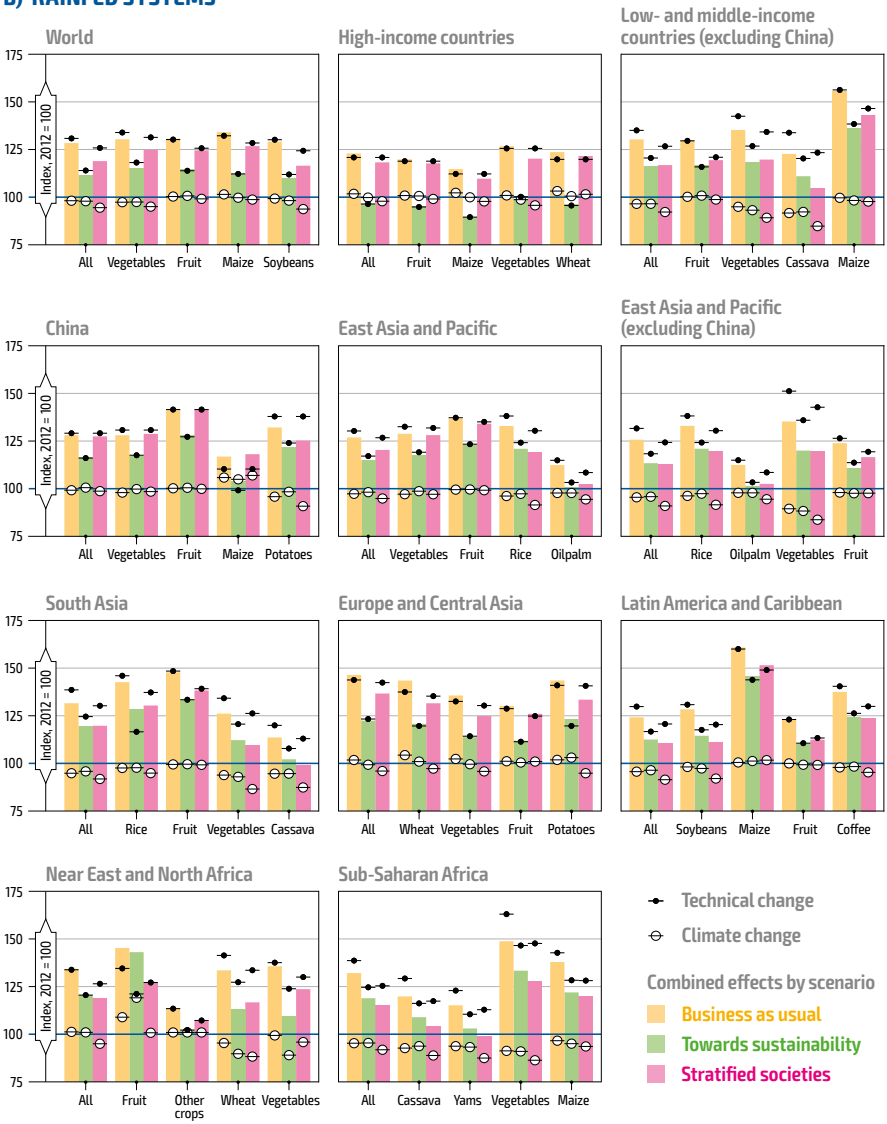
FIGURE 3.9 YIELD CHANGES FROM 2012 TO 2050 DUE TO CLIMATE CHANGE AND TECHNICAL PROGRESS

A) IRRIGATED SYSTEMS



Note: Coloured bars indicate price-independent changes in yields attributed to both technical progress and climate change. The white circles indicate changes in yields arising from climate change, while the black barred dots indicate changes arising from technical progress. Climate change impacts are computed from FAO-IIASA GAEZ v4 (scenario without CO_2 fertilization, median value for five climate models). Changes in yields are shown for the four top commodities, as classified in the FAO GAPS model, in each region, and production system, ranked by their value of production in 2012. In this figure, "Citrus"

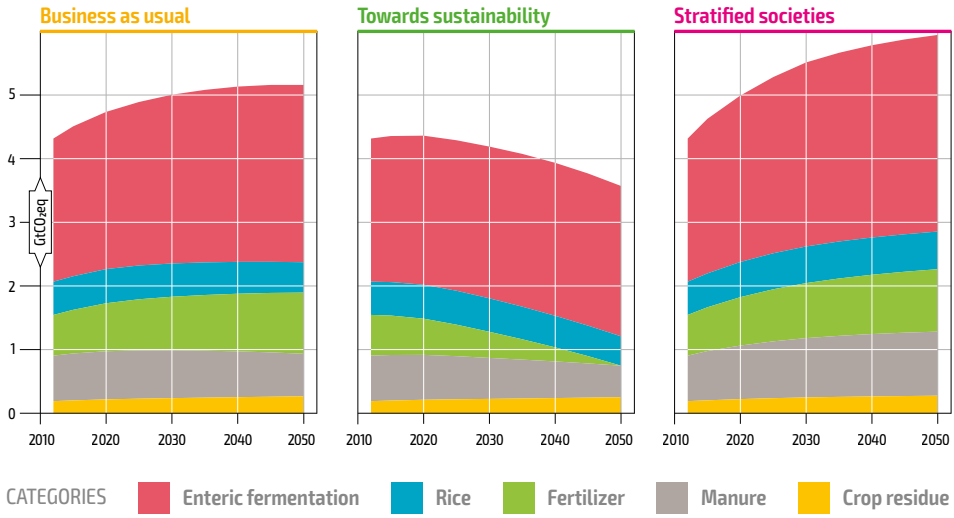
B) RAINFED SYSTEMS



and "Other fruit" are aggregated into "Fruit". "All" refers to the aggregated change in production over the total harvested areas for all crops. Note that the results of research into the impacts of climate change on fruit trees are not conclusive (Ramírez and Kallarackal, 2015).

Sources: FAO Global Perspectives Studies, based on FAOSTAT (various years) for historical crop yields and value of production; FAO-IIASA GAEZ v4 for climate change shifters; FAO expert judgement for technological shifters.

FIGURE 4.17 **PROJECTED AGRICULTURAL GREENHOUSE GAS EMISSIONS FOR DIFFERENT SCENARIOS**



Notes: Emissions are expressed in gigatonnes (billion metric tonnes) of carbon-dioxide equivalent ($GtCO_2eq$). The graph includes GHG emissions from livestock and crop production but excludes emissions from burning of savannah and crop residues and conversion of peatlands.
Sources: FAO Global Perspectives Studies, based on simulations with the FAO GAPS model, and emission factors from FAO GLEAM (2017) and FAOSTAT (various years) .

The wide range across countries and regions of emission intensities, which are the amount of GHG emissions per unit of output, suggests that there is a potential to lower GHG emissions from food and agricultural sectors. This implies examining the overall impacts of the food and agricultural systems at large, which include food and feed demand, food loss and waste, other uses of agricultural outputs (fibres, biofuels, etc.), water usage, as well as the system's effects on soil health, ecosystem services, biodiversity and agriculture–forest trade-offs and/or synergies, including soil carbon storage, afforestation and reforestation.

Agriculture, land use, land-use changes and forests are among the most referenced sectors in intended nationally determined contributions (INDCs) as domains for GHG emission reductions that countries submitted ahead of the 2015 United Nations Climate Change Conference (COP21) (FAO, 2017h). Options for significantly reducing GHG emissions exist also for fisheries, for instance in capture, by using more efficient engines, improving vessel shapes or simply by reducing the mean speed of vessels, as well as in aquaculture, by using renewable energy sources, and improving feed conversion rates (Barange *et al.*, 2018). However,

all these aspects need to be further mainstreamed to allow for the effective implementation of INDCs and to achieve further results in GHG reduction.

Furthermore, it is apparent that, although the agricultural sectors have significant potential to contribute to overall GHG emission reductions, the burden of this challenge must be borne by the economy at large. This implies, for example, achieving economy-wide improvements in the efficiency of energy use – that is, the energy use per unit of output, as well as the GHG emissions efficiency per unit of energy.

HAITI
Hurricane impact and humanitarian assitance.
©UN Photo/Marco Dormino

7. CONCLUDING REMARKS

"Business as usual" is no longer an option if the targets set by the 2030 Agenda for Sustainable Development – and specifically those directly concerning food and agriculture – are to be met. The high-input, resource-intensive farming systems that have caused massive deforestation, water scarcity, soil depletion, the loss of biodiversity, antimicrobial resistance of pests and diseases and high levels of GHG emissions cannot guarantee the sustainability of food and agricultural systems. Moreover, a future of increasing inequalities, exacerbated climate change effects, uncontrolled migration, increasing conflicts, extreme poverty and undernourishment, as outlined in one of the scenarios of this study, is highly undesirable.

Innovative systems are needed to increase productivity without compromising the natural resource base. Technological improvements resulting in a drastic reduction in agricultural GHG emissions would help to address climate change and counteract the intensification of natural hazards, which affect all ecosystems and every aspect of human life (FAO, 2017a). These are the salient features of the "towards sustainability" scenario developed and analysed in this report to reflect a future with desirable outcomes.

However, this scenario is far from being an easy path without hurdles: there are no "silver bullets" and society must be prepared to address certain trade-offs. The conclusions of this report provide solid evidence to corroborate the assertion that "fundamental changes in the way societies consume and produce are indispensable for achieving global sustainable development" (UN, 2012).

To permanently and universally achieve the SDGs and thereby guide food systems and socio-economic systems in general along an economically, socially and environmentally sustainable path, a global transformative process that goes well beyond the divide between "developed" and "developing" countries is required. Where the conventional "development" wisdom once focused mainly on addressing the needs of low-income countries, sustainable development looks at the universal challenge – and collective responsibility – of addressing the needs of all countries. All socio-economic and environmental systems require substantial investments along the path towards sustainability to overhaul obsolete capital stock, research and develop new solutions, and implement innovative technologies adapted to different contexts and actors. These aspects are all at the heart of the SDGs.

The investments required to move food and agricultural systems towards sustainability are by nature riskier than in other sectors, and require a

better *ex ante* risk assessment and guarantees to ensure that projects are sustainable. Moreover, these investments will only materialize if both private and public funding becomes available to:

- research and develop innovative sustainable technologies for primary production and processing;
- replace obsolete capital to improve efficiency in land and water use;
- reduce GHG emissions along the entire food and agriculture value chains;
- build market and logistical infrastructure to reduce food losses and improve value chain efficiency;
- support the implementation of social protection programmes and increase their coverage, especially in rural areas;
- reinforce institutions, including those promoting responsible investments in agriculture and food systems.

Making this funding available requires sacrificing certain present – not necessarily essential – needs in order to reap future benefits. Such sacrifices should be borne by richer countries and by the better-off segments of society, which can reasonably afford them. As such, a brighter future is prepared for the next generations and for those who already suffer from the negative effects of unsustainable development.

The findings of this report are subject to uncertainties regarding the interaction between various production, consumption and biophysical processes occurring across different sectors and regions. Moreover, as data on many aspects are insufficient or inconsistent, it was necessary to identify, merge and harmonize a myriad of datasets from different domains.

To avoid looking into the future with the same lenses used to observe the past, and to overcome data gaps, this report was based on the ideas, positions and contributions of a broad array of actors and constituencies, including other international organizations, national governments, non-governmental and civil society organizations, and academia. It builds heavily upon the multidisciplinary knowledge of FAO and its development partners, which in many instances represent the best and most up-to-date information available worldwide in fields such as animal production technologies and related GHG emissions, climate change scenarios, agricultural commodity production and use, and global economic data, to mention but a few.

Despite its difficulties and limitations, this report contributes to the debate on the future of food and agriculture and its sustainable development patterns. Much more remains to be done to better understand how socio-economic and environmental systems may evolve in the future, and comprehend the possible future pathways of food and agricultural systems. Nonetheless, this report

constitutes a significant step forward in this direction. For the first time does a report not only provide a globally comprehensive and consistent foresight exercise on food and agricultural systems based on three alternative scenarios – which catalyses such a large amount of multidisciplinary expertise – but it does so by examining the challenges to food security and nutrition in all their complexity and within the context of the wider economy, taking into account future climate change.

This report advocates for more sustainable food and agricultural systems based on sound quantitative evidence. The absence of such evidence would make any calls for increased sustainability much less convincing and, ultimately, largely ineffective.

Hopefully, the findings of this report will be of use to everyone interested in long-term foresight assessments of global food and agricultural systems, including decision-makers and analysts in governments, international organizations, civil society organizations, the private sector, and academic and research institutions. Decision makers, the international community, academia and civil society are invited to consider this report not as the end point of an analytical endeavor, but rather as the starting point for a dialogue on strategic policy choices and processes aimed at shaping sustainable development patterns at country, regional and global levels. It is in this perspective that this report should be regarded as a contribution towards achieving both the United Nations' Sustainable Development Goals and FAO's vision of a world with sustainably produced, nutritious and accessible food for all.

ITALY
Food for the future.
©FlickCC/Maja Dumat

THE FUTURE OF FOOD AND AGRICULTURE ALTERNATIVE PATHWAYS TO 2050

This report explores three different scenarios for the future of food and agriculture, based on alternative trends for key drivers, including income growth and distribution, population growth, technical progress and climate change.

Building on the report *The future of food and agriculture – Trends and challenges*, this publication forms part of FAO's efforts to support evidence-based decision-making processes. It provides solid qualitative and quantitative analysis and sheds light on possible strategic options to achieve the Sustainable Development Goal of eradicating hunger, improving nutrition and ensuring economic, social and environmental sustainability of food and agricultural systems.

The publication *The future of food and agriculture – Alternative pathways to 2050* is available at:
www.fao.org/3/I8429EN/i8429en.pdf

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