Strategic Thinking for the Review of FAO's Strategic Framework

ANNEX I

Major Global Trends and Challenges

to

Food Security and Nutrition, Rural Welfare, the Sustainability of Agriculture, and its Natural-Resource Base[1]

[1] This document is an advanced, unedited draft and part of a larger study to be published end November 2016.

Contents

Introduction

The first draft of this document on relevant trends to food and agriculture was prepared under the general coordination of the Office of Strategy, Planning and Resources Management with wide collaboration of other units of the Organization, including Regional Offices. The assessment of the global trends and challenges as presented in this document builds on inputs from all technical departments and divisions at FAO. The inputs were coordinated by the Agricultural Development Economics Division (ESA) of the Economic and Social Development Department, with much of the efforts owing to the Global Perspectives (GPS) team.

A first draft was presented to the Strategic Experts Panel (SEP)[2] convened on September 9 and 10, 2016. The Panel expressed its appreciation for the document and expressed that "the document is an example of FAOs extraordinary capacities to mobilize information and knowledge", and recommended that it be made public.

The document has fifteen chapters. Chapter 1 identifies and briefly describes some of the major global developments that are shaping the world. It describes the big picture within which the more specific issues and problems that comprise FAOs mandate have to be analyzed and interpreted. This chapter provides a sketch of the broader context of global development trends that will influence the future of the planet and human progress, of which agriculture and food security form a part.

Chapters 2 to 14 identify and describe with considerable detail thirteen global trends, which are considered to be the most important determinants of how agriculture, food security, rural welfare and natural resource base issues will evolve, the problems that emerge and the challenges and opportunities that are present.

[2] SEP members: Alain de Janvry, Professor, University of California at Berkley; Ismahane Elouafy, Director General, International Center for Biosaline Agriculture; Shenggen Fan, Director General, IFPRI; Gustavo Gordillo, Consultant; Marion Guillou, President Agreenium; Mulu Ketsela, Executive Director ADB; and Martin Piñeiro , Special adviser to FAO Director-General

1 Global development and the future ahead

Over the past century, enormous progress has been achieved in improving human welfare worldwide. Societies have changed radically thanks to quantum leaps in technology, urbanization and innovations in production systems. Yet, conditions in today's world are a far cry from a world "free of fear and want" envisioned at the foundation of the United Nations.

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

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

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

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

Agriculture and food systems have already changed significantly in recent decades and will need to adjust further in this evolving global context.. Agricultural production more than tripled between 1960 and 2015, owing in part to productivity-enhancing Green Revolution technologies and a significant expansion of the use of land, water and other natural resources

for agricultural purposes. The same period witnessed a remarkable process of industrialization and globalization of food and agriculture. Food supply chains have lengthened dramatically as the physical distance from farm to plate has increased and as the consumption of processed, packaged and prepared foods has increased in all but the most isolated rural communities.

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

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

All of these negative trends are accelerating in pace and intensity, and agriculture is an important part of the problem. Deforestation, mainly for farming, produces a significant part of global greenhouse gas emissions and causes the destruction of habitats, species and biodiversity in general. The incidence of natural disasters has increased fivefold since the 1970s. Deforestation, the degradation of natural coastal protection and poor state of infrastructure have increased the likelihood that weather shocks will become disasters for communities and the economy. The lengthening of food chains and changes in dietary patterns have further increased the resource-, energy-, and emission-intensity of the food system at large.

All of these trends, in turn, threaten the sustainability of food systems and undermine the world's capacity to meet its food needs. Although the full implications of climate change on agriculture, forestry and fisheries are difficult to predict, it is expected that impacts will be different for each region, ecological zone and production system. Even small changes in the climate – e.g., through small changes in annual rainfall or in seasonal precipitation patterns – can affect productivity.

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

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

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

This raises further questions, this time about policy coherence. Can we overcome 'wickedness' in policy making, where the lack of a coherent set of well-defined goals and processes means that the response to one aspect of a problem (for example, incentives to raise productivity) risks exacerbating others (such as depletion of natural resources)? Can we engage all stakeholders, including, the private sector, farmer and consumer organizations, and other civil society players, in better decision-making, recognizing that more inclusive governance is essential to improving dialogue about the hard policy choices that need to be made?

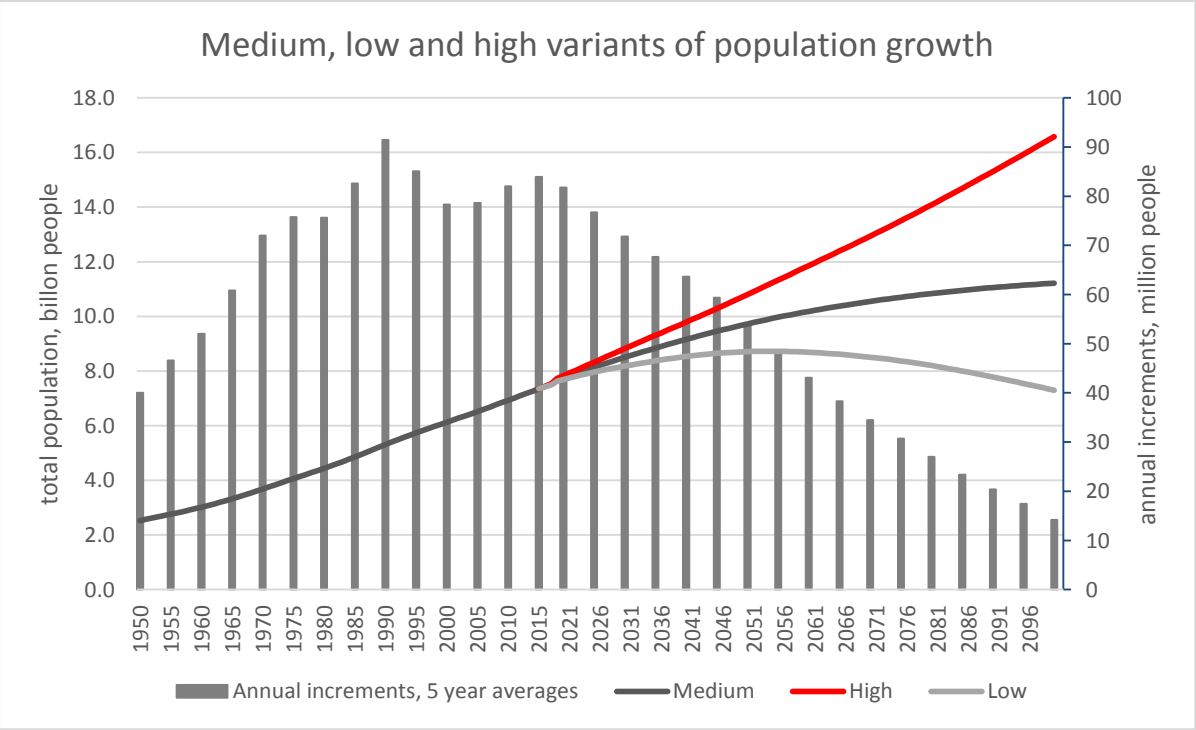
2 Population growth, urbanization and ageing

2.1 Global and regional population growth

FAO, in its forward looking exercises has always considered population dynamics, not only in absolute terms but also in its diversified regional paths, its structure by age groups and location in rural and urban areas, as a key driver of changes in food and agriculture[3]. Population growth therefore deserves a special attention in the analysis of future trends.

The United Nations Population Division, offers three different population growth scenarios, known as the low, medium and high variants. Figure 2.1 provides the past evolution and the expected trends for all three variants. Such different population growth scenarios are an important starting point for many analyses and projection exercises and they are frequently used to illustrate and evaluate different future scenarios[4].

Figure 2.1 Global population growth to 2100, increments and different variants



Source: UN-DESA Population Division

[3] See for instance the series of FAO reports "World agriculture towards 20XX", with its most recent release "World agriculture towards 2030/2050: the 2012 revision": http://www.fao.org/docrep/016/ap106e/ap106e.pdf , hereafter referred as AT2050, or the report FAO-IFAD-WFP, 2015 "Achieving Zero Hunger: the critical role of investment in social protection and agriculture. http://www.fao.org/3/a-i4951e.pdf

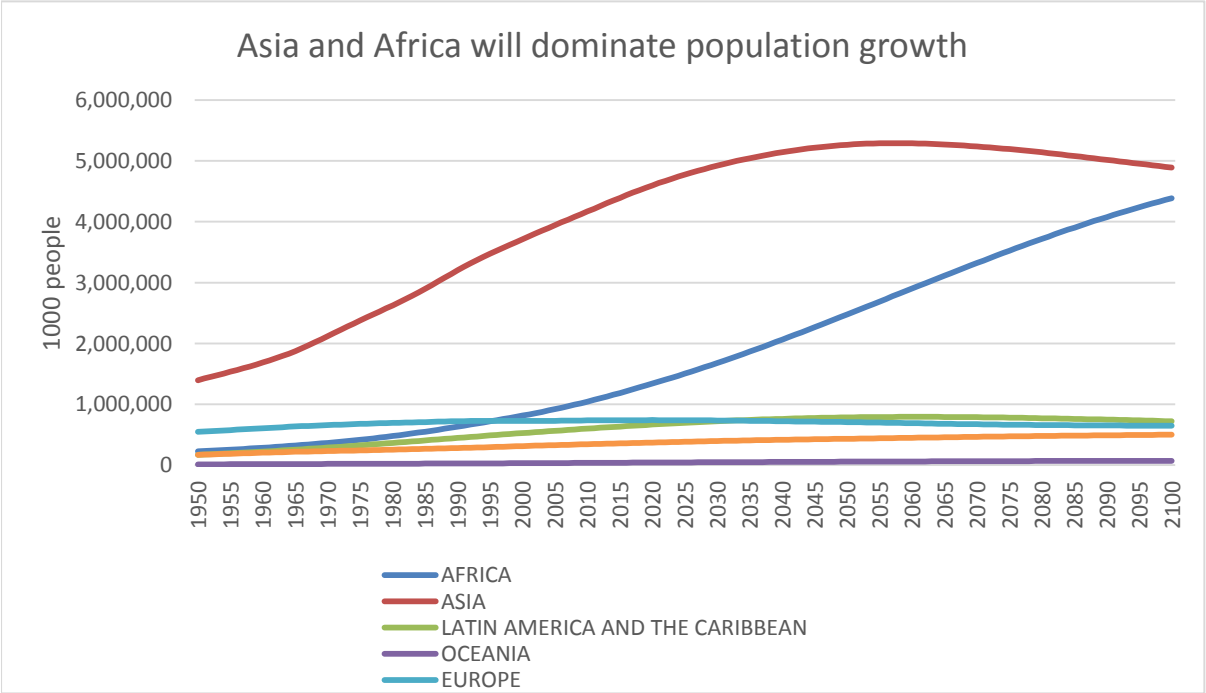
[4] For this analysis, for sake of simplicity, reference will mostly be made to the medium variant.

For the world as a whole, annual population growth rates have been declining for nearly five decades. At the highest point in the late 1960s, global growth rates reached 2 percent per year, with total fertility rates (TFR) at levels of 4.45 [5]. As TFRs declined to 2.5 by 2015, population growth rates fell to 1.2 percent per year globally. While population growth rate have been declining for several decades, the absolute annual increments continued to rise and started to decline in a noticeable fashion only recently. Currently, the absolute annual increments are only slightly below 80 million people. The medium variant suggests a gradual decline in the absolute increments to a little more than 55 million people by 2050, and then further down to 15 million by the end of the century. These increments translate into a world population of 9.73 billion people by 2050 and 11.2 billion by 2100.

Marked differences in population growth across regions. The global trends mask considerable differences across and within regions, including between high-income and middle and low-income countries. While the high-income countries would reach their maximum population size by 2040, low and middle income countries would see only slow declines in growth over the medium and even the longer term. But there are also considerable differences in population growth within low-income countries. Asia, the most populous continent would reach its population peak between 2050 and 2060 (figure 2.2). Within Asia, East Asia is expected to see a further and faster slowing of growth rates and could see a shrinking overall population after 2040. As UN population growth estimates highlights, South Asia will continue to grow beyond 2070 and only reach its zenith thereafter. Growth is also expected to slow in Latin America, but more moderately and it will take until 2060 before the region reaches its maximum population size. Even faster and more durable growth is projected for the Near East and North Africa region, where population growth comes to a halt only after 2080. The only region where the maximum population size will not be reached within this century is Africa. While also there growth rates continue to decline, Africa's population is set to grow beyond the end of the century and in excess of the 2.2 billion it is expected to reach by 2100. The net effect across all regions will be a continuously growing global population, possible exceeding a total of more than 11.2 billion people by the end of the century.

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

Figure 2.2 Population growth by region, medium variant



Source: UN-DESA, Population Division.

… and within regions. The differences within regions seem to be even more pronounced than the differences across regions, as shown in Table 2.1. Some countries are currently projected to grow so rapidly that their populations would reach multiples of their current levels by 2050. At the top of the list of fast growing populations is Niger, with growth rates of 3.75 percent between 2015 and 2050, and 2.12 percent thereafter. This would lift its total population, according to the medium variant, from currently 20 million people to 72 million by 2050 and 209 million people by 2100. Growth rates of more than 2.5 percent p.a. to 2050 are also expected for Senegal, Gambia, Chad, Somalia, Malawi, the Democratic Republic of the Congo, Burundi, United Republic of Tanzania, Mali, Uganda, Angola and Zambia. All these countries are located in sub-Saharan Africa, many of them in the central and eastern African area. The combined population of these countries reached 320 million people in 2015. It will nearly double to 2050 and more than redouble by 2100. By then it will reach a total of 1.8 billion (Table 2.1)[6].

[6] In addition to these 13 African countries, a few Asian ones also currently display annual population growth rates above 2.5%: Afghanistan, Iraq, Lebanon, several small states in the Persian Gulf.

Table 2.1: African Countries with population growth rates above 2.5 percent to 2050

	Total population (thousands)			Growth rates in percent p.a.	
	2015	2050	2100	2015 -2050	2050 -2100
Senegal	15,129	36,223	75,042	2.53	1.47
Gambia	1,991	4,981	8,896	2.65	1.17
Chad	14,037	35,131	68,927	2.66	1.36
Somalia	10,787	27,030	58,311	2.66	1.55
Malawi	17,215	43,155	87,056	2.66	1.41
Democratic Republic of the Congo	77,267	195,277	388,733	2.68	1.39
Burundi	11,179	28,668	62,662	2.73	1.58
United Republic of Tanzania	53,470	137,136	299,133	2.73	1.57
Mali	17,600	45,404	92,981	2.74	1.44
Uganda	39,032	101,873	202,868	2.78	1.39
Angola	25,022	65,473	138,738	2.79	1.51
Zambia	16,212	42,975	104,869	2.82	1.80
Niger	19,899	72,238	209,334	3.75	2.15
TOTAL	**318,841**	**835,564**	**1,797,547**	**2.79**	**1.54**

Source: UN-DESA, Population Division.

Should these population projections materialize, population increases would be likely to jeopardize the overall development prospects of these countries in a serious manner. As all of these countries rely significantly on agriculture for employment and national incomes, it would also put their prospects for improved food security and nutrition into question. Particularly difficult would be those agriculture-dependent countries with a limited natural resource base, i.e. notably those with limited land and water resources. Countries like Niger or Somalia fall into this rubric. On current trends, these countries could be confronted with a neo-Malthusian future, that is, rapid population growth in the midst of limited resources leading to persistent undernourishment if relying on domestic production only.

One option to eschew such an outcome would be faster than assumed outmigration from these countries. With rapid population growth, these flows could see rapidly rising volumes. Their impacts are already being felt in some immigration destinations, not only in their geographic vicinity, but also abroad, notably in Europe and other OECD countries. Alternatively, these countries would need to make greater efforts to address their high population growth rates and actively invest in family planning and reduction of child mortality, especially in rural areas. In any case, these countries are likely to remain dependent on significant foreign assistance to better feed their domestic populations and/or control their population growth.

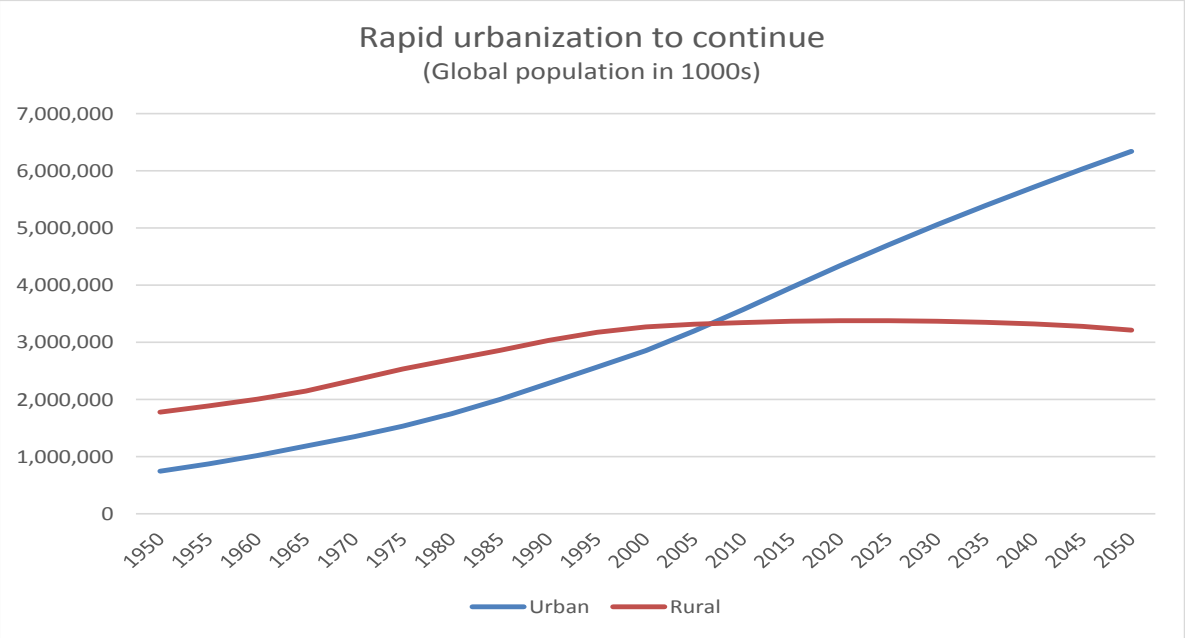
Agricultural and rural development strategies in Sub-Saharan Africa will need to more fully anticipate the implications of the region's rapidly changing demographic situation, and the immense challenges that rising population/land densities pose in the context of unsustainable agricultural intensification, a rapidly rising labour force resulting from the region's current demographic regime, and limited non-farm job creation. These challenges are manageable but will require explicit policy actions to address the unique development challenges in densely populated rural areas.

2.2 Urbanization

For decades, the world's population was predominantly rural. Only 35 years ago, still more than 60% of all people lived in rural areas. Since then, the urban-rural balance has changed markedly and today slightly more than half of the global population (54%) is urban. By 2050, i.e. 35 years from now, the world couild be predominantly urban with more than two-thirds of all people living in urban areas[7]. Changes in agriculture, notably technical progress and the adoption of labour-saving technologies, have been a key driver for this rising urbanisation trend; at the same time, agriculture, food and nutrition are and are likely to continue be affected by the changes brought about by urbanization.

In absolute terms, global urbanization to 2050 could amounts to net addition of 2.4 billion people to urban areas, which is more than the total global population increment of 2.2 billion people. This means that rural populations may see a net reduction of nearly 0.2 billion people (see also Figure 2.3). The net reduction of rural populations reflects much more than simply an outflow from rural to urban areas. It is driven by a variety of factors, notably higher mortality rates in rural areas as well as shorter life expectancies. These factors more than offset the lower urban fertility rates.

Figure 2.3. Projected Global urbanizaton to 2050, medium variant (Thousand people)



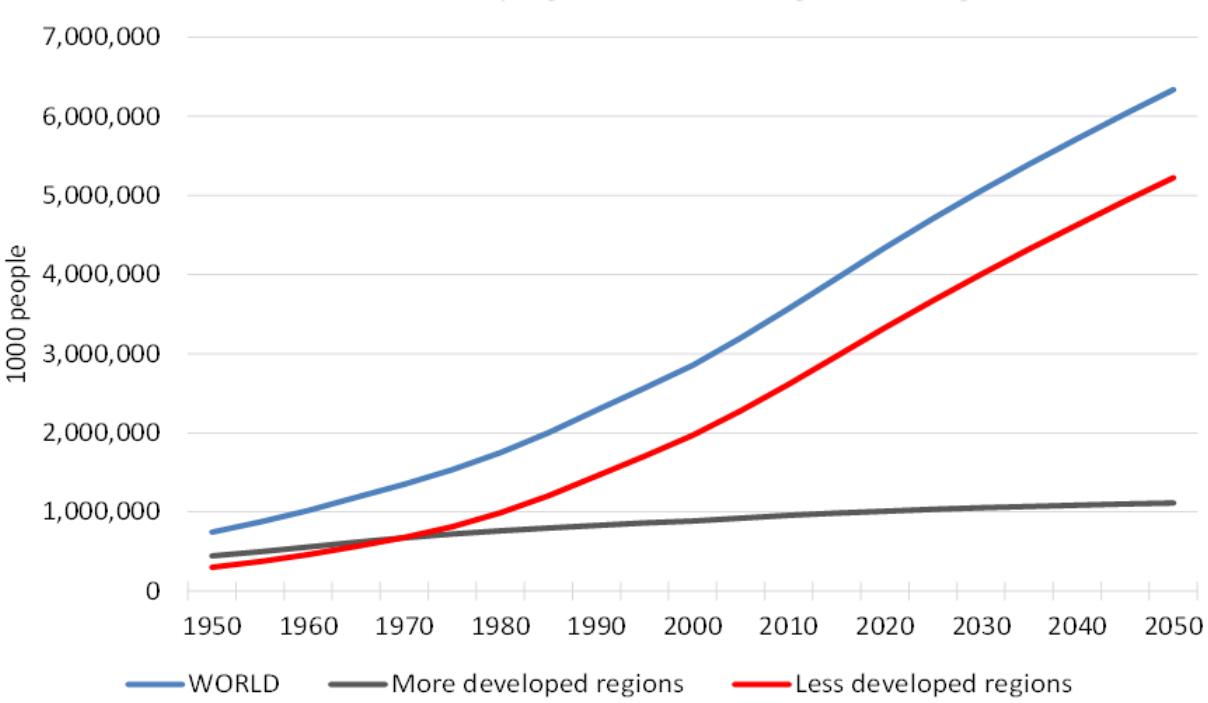
Source: UN-DESA, Population Division.

Urbanization is likely to largely become a low-income country phenomenon. While urbanization was a high-income country phenomenon up to the 1970s, the rapid growth of urban populations in low-income countries has in the meantime become the defining feature of the

[7] UN-DESA Population Division (2015): World Urbanization Prospects: The 2014 Revision. While this shift has been discussed and analysed widely, there is little appreciation for the quality of the underlying data. Importantly, urban/rural estimates and hence the projected urbanization trends are not based on a uniform definition of urban versus rural populations. Instead, individual countries report their data based on national definitions and no effort has been made to make these estimates comparable across countries or regions.

global urbanization dynamics. The sheer size that urban populations have reached in low-income countries now also determines the global dynamics (**Error! Reference source not found.**Figure 2.4).

Figure 2.4 Urbanization in low and high-income and midle and low-income countries



Source: UN-DESA, Population Division

While urbanization has become a low-income country phenomenon, the overall aggregates mask important differences across regions. Traditionally, Latin America has been the most urbanized low and middle-income region. Particularly South America urbanized early and rapidly. By 1980, more than two thirds of its population were classified as urban, a share that has risen to nearly 85 percent by 2015. But the high degree of attained urbanization also means that urbanization rates will further decline and additional future urbanization will remain small**,** while low-urbanized areas may urbanize faster in the future.

Urbanization, food consumption and agriculture. Urbanization has a direct impact on food consumption patterns. Higher urban wages increase the opportunity costs of preparing food and hence favour food products that encapsulate a large amount of labour. This supports convenience-, street-, and fast-food. With these changes, the nutrient content of a diet is changing, typically towards more salt, fat and sugar and in general, more energy-dense diets[8].

This also means a shift in employment within the food system, with fewer people working in agriculture and more working in transport, wholesaling, retailing, food processing and vending[9].

[8] A more thorough discussion of implication of urbanization on food systems is provided in chapter 2.9.

9 Cohen M., Garrett J. 2009 *The food price crisis and urban food insecurity*. London, UK: IIED

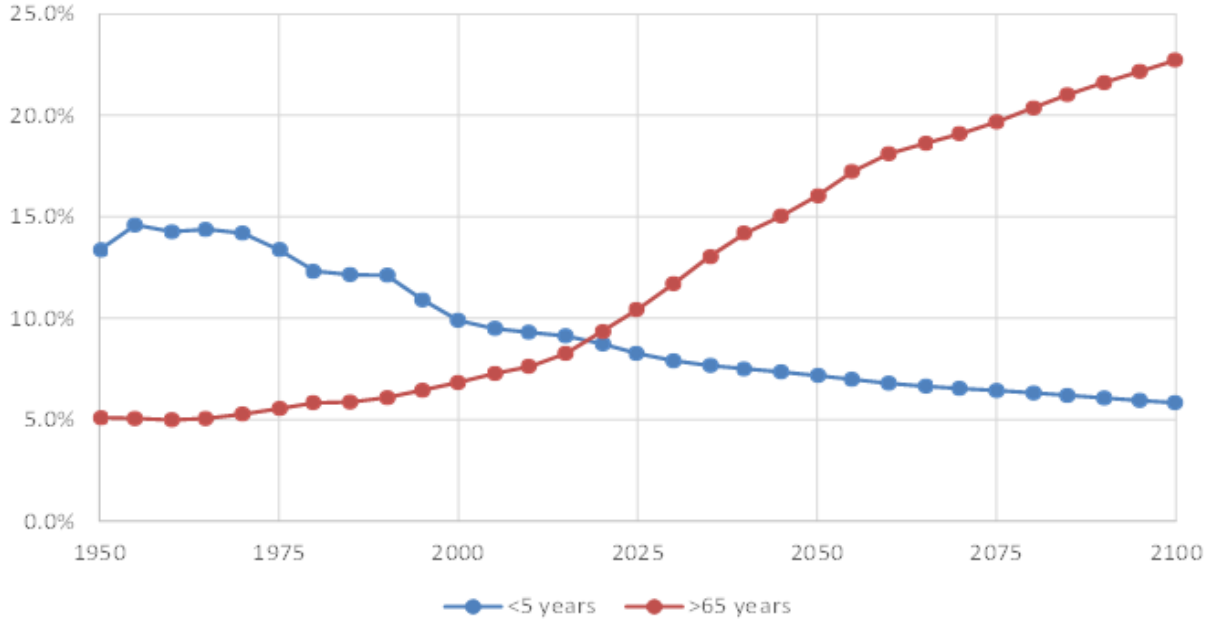
2.3 Ageing

Over the decades to come, the world is likely not only to be more populous and urban, but also be demographically older, at least on average. This is not a new trend. From 1950 to 2015, the share of children below the age of 5 years declined from 13.4 percent to 9.1 percent, while the proportion of older (65+) people rose from 5.1 percent to 8.3 percent. Going forward, this development is expected to accelerate and, by the end of the century, the share of young children could decline to 5.8% while the proportion of older people is forecast to rise to 22.7 percent (Figure 2.5).

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

For many decades, ageing in many high-income countries was a success story. People were and are living longer and generally healthier lives. They have benefited from improved nutrition, access to public health, and medical advancement resulting in steadily growing life expectancies. Their societies enjoyed a large and healthy work force contributing to income growth and being able to support a rather small dependent population (older people for pensions and health, young people for education). These trends are now changing. With ageing, the economic growth potential of these economies slows and their pay-as-you-go-financed social security systems become unsustainable, as well as the growing health-care burden.

Figure 2.5. Global ageing to 2100 age groups as share of total population



Source: UN-DESA, Population Division

Compressed ageing in low-income countries. While these challenges appear huge, most high-income nations have had decades to adjust to these changes in their age structures. For example,

it took more than a century for France's population age group of 65 and above to increase from 7 to 14 percent of the total population. In contrast, many low-income countries are experiencing a much more rapid increase in the number and percentage of older people. This "compressed ageing" poses additional challenges. Social support systems must adapt quickly to accommodate a new age structure, often without having reaped demographic dividends available to the slowly ageing high-income economies. Many low-income countries may not reach the income levels of high-income countries in the foreseeable future, in other words they will "grow old before they can grow rich".

Ageing in rural areas tends to start earlier and proceed faster than national averages would indicate. Rural ageing has major implications for the composition of the rural labour force, patterns of agricultural production, land tenure, social organization within rural communities, and socio-economic development at large. The problem of an ageing agricultural labour force is that challenges such as environmental degradation, climate change and limited agricultural technology tend to affect older farmers more than their younger, healthier and better-educated counterparts. This may be compounded by discrimination against older rural people in accessing credit, training, and other income-generating resources. Processes such as diffusion of new agricultural technologies and introduction of improved seeds and tools often bypass older farmers, as many have neither the financial resources to buy additional inputs, nor the skills (for example, literacy) and energy to invest in adopting new practices. Because of gender divisions in agricultural production that influence opportunities to obtain credit and training, or to participate in market exchanges, older women are particularly disadvantaged. It follows that in countries where the agricultural labour force is ageing, there is an urgent need to adapt farming technologies and agricultural policies to the capacities and needs of older farmers[10].

Need to create many millions of jobs. Arguably the single biggest global development challenge for the decades to come arises from the need to integrate hundreds of millions of young people into the labour market. Over the next 35 years, the age bracket between 15 and 24 years may rise from the already high level of about 1 billion people in 2015 to 1.2 billion by 2050[11]. Most of these young people will live in sub-Saharan Africa and South Asia. Most of them will probably be born in rural areas, where jobs would be arguably more difficult to find. Without rural jobs, these countries may become the source of intra-national migration and premature urbanization, possibly causing integration problems at home, or international migration and integration challenges in countries abroad.

[10] Anriquez G., L.Stloukal (2008). Rural population change in developing countries: lessons for policy making. FAO ESA working papers 08-09, November 2008. ftp://ftp.fao.org/docrep/fao/011/aj981e/aj981e00.pdf

[11] Source: UN-DESA, Population Division

3 Economic growth, investment and trade

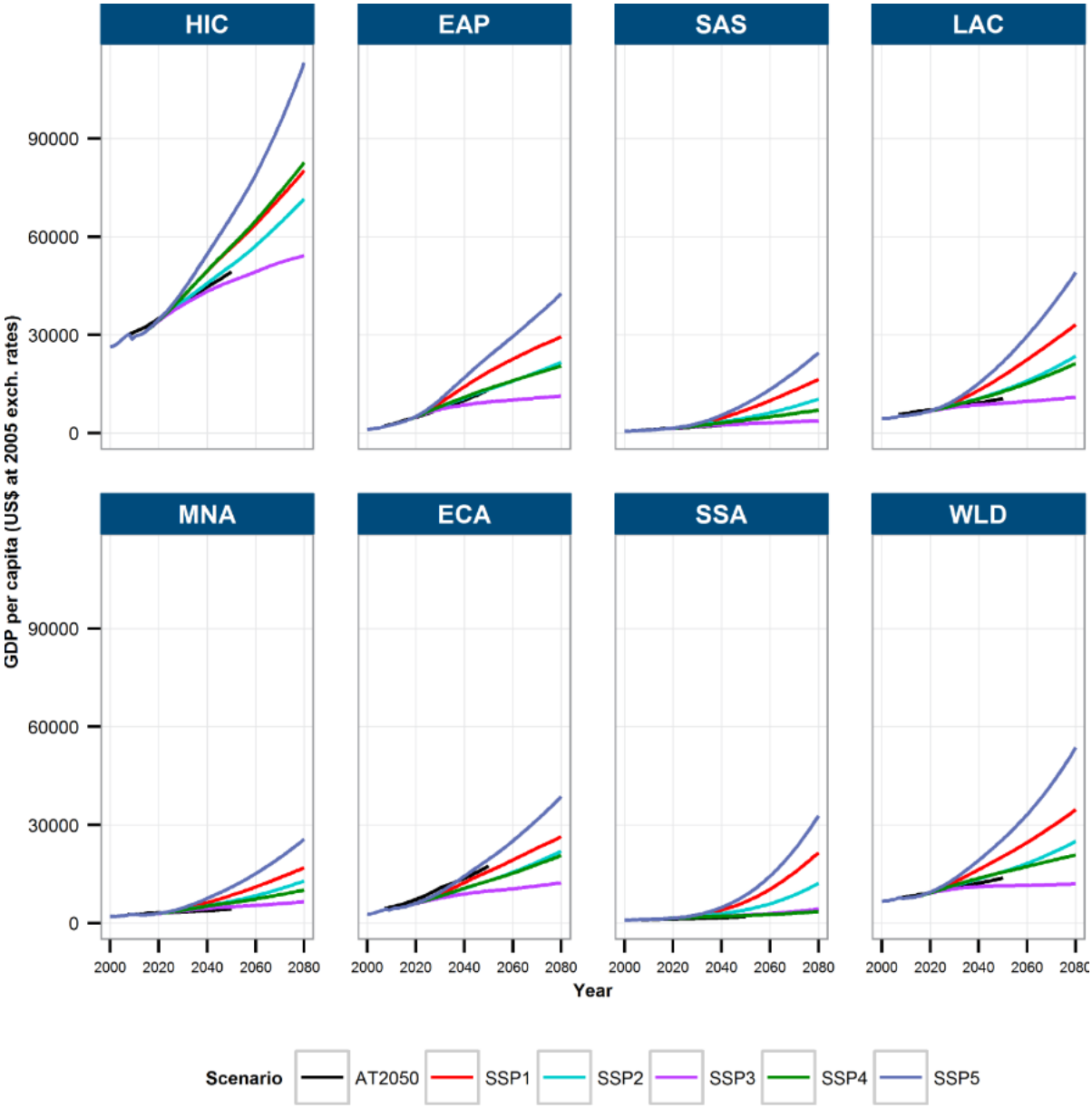
3.1 Long-term economic projections

Projections of future global, country-wide and per capita income fit by definition in the domain of uncertainty. The paths that economic systems will follow depend on a wide range of interrelated factors, such as the behaviour of agents, both producers and consumers, the future availability and productivity of the resource base, population growth and related geographic dynamics, interrelations among different groups of countries such as the development of future conflicts or the establishment of international agreements, the evolution of knowledge and technology-related know-how, climate changes, the evolution of institutions governing social and economic systems and, more in general, the possible strategies and policies that governments could adopt in response to the above-mentioned dynamics. Therefore, long-term economic projections make sense only if casted in scenarios of possible alternative futures determined by the occurrence of a combination of these factors. The OECD, in the context of climate change forward-looking exercises related to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), has recently developed projections for country-wide GDP and population to 2100 on the basis of five alternative scenarios. These are the so called "Shared Socioeconomic Pathways" (SSPs). Each scenario depicts a possible alternative future, comprising: a future characterized by global sustainability (SSP1), a "Business as Usual" or "middle of the road" scenario (SSP2), a scenario characterized by international fragmentation (SSP3), a future characterized by increasing intra and between-country inequality (SSP4) and a scenario where fossil energy will remain the main source of energy (SSP5) (O'Neil et al, 2015)[12]. The GDP and population projections related to the various SSPs are reported in a database available at the International Institute for Applied Systems Analysis (IIASA) [13].

As visible in figure 3.1, the resulting per capita income projections to 2080 widely wary both across scenarios and country groups. So, for instance, projections for the SSP2, the so called "middle-of-the-road" scenario, show per capita GDP increases from the base year (2000) up to +132% by 2050 (at 1.9% annual growth rate) and more than double with respect to the base year (2000) in 2080. SSP5 instead, a quite extreme growth scenario, projects per capita income to more than triple to 2050 and increase up to more than five times to 2080, while SSP3, characterized by overall fragmentation of the world in regional and sub-regional groups, projects much lower per capita income increases to 2050 and 2080.

[12] O' Neil et al, 2015. The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century.
[13] https://secure.iiasa.ac.at/web-apps/ene/SspDb/dsd?Action=htmlpage&page=about

Figure 3.1. Per capita GDP projections under alternative pathways and in AT2050



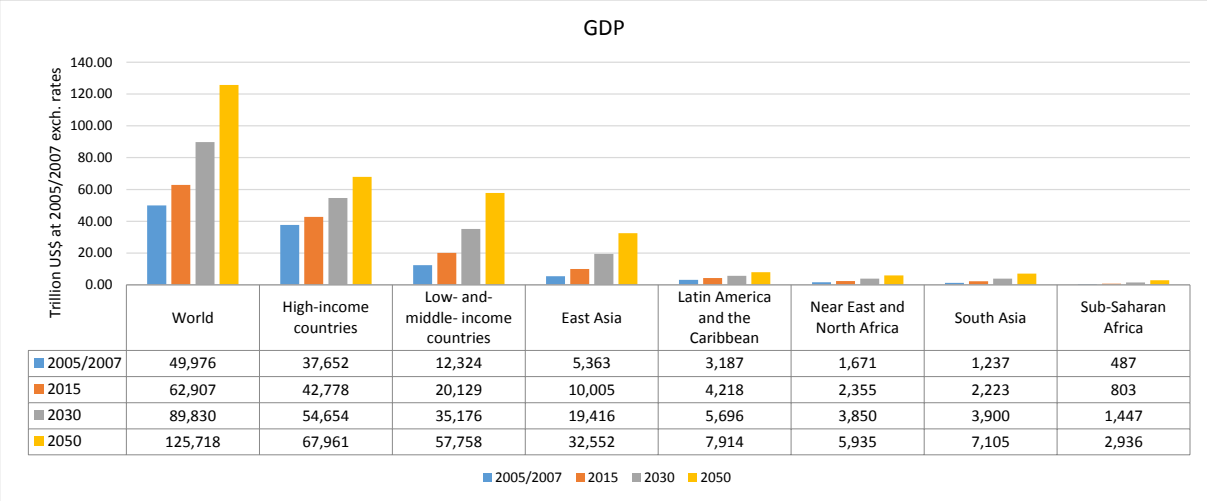
Source: FAO Global Perspectives Studies (unpublished), based on SSP database-OECD projections (2012) and AT2050.

To project future patterns of agricultural demand and supply, FAO, in the AT2050 report adopted fairly conservative projections of GDP and per capita GDP estimates, at least compared to the range of values presented for SSPs, where the gross global product is expected to shift from almost 50 trillion US$ in 2005-7 to almost 126 trillion in 2050, exhibiting an average annual growth rate of more than 2% (figure 3.2). However, these projections assume that in absolute terms there will be some form of convergence in GDP across the various regions. For instance, high income countries, which GDP is assumed to shift in the period 2005-7 to 2050 from 37.7 to less 70 trillion US$, at an average annual growth rate of around 1.35%, are expected to enjoy only enjoy 54% of the gross world product in 2050, while they enjoyed more than 75 % in 2005-7. This is due to the fact that low and middle income countries are expected enjoy a faster annual economic growth rate of almost 3.6% an In the same vein, Sub-Saharan

Africa would shift its share of gross world product from less than 1% to 2.34%, thanks to its comparatively high growth rate of 4.17% .

However, these projections also assume divergent patterns within low and middle income regions. For instance, East-Asia in 2005-7 accounted for US$ 5.4 trillion GDP, which is 43% of the total low and middle-income countries GDP. Its GDP would increase to 32.6 trillion US$ in 2050 with an annual growth rate of around 4.2%, so its share within low and middle-income countries would increase to 56%. Similarly Sub-Saharan Africa would increase its share from less than 4% of GDP of low and middle income countries to more than 5%. Other regions such as Latin America and the Caribbean, are projected to grow at lower annual rates, around 2 percent. At these different speeds, the gap between East-Asian countries, and the other low and middle income countries is expected to widen.

Figure 3.2: Long-term GDP projections by region

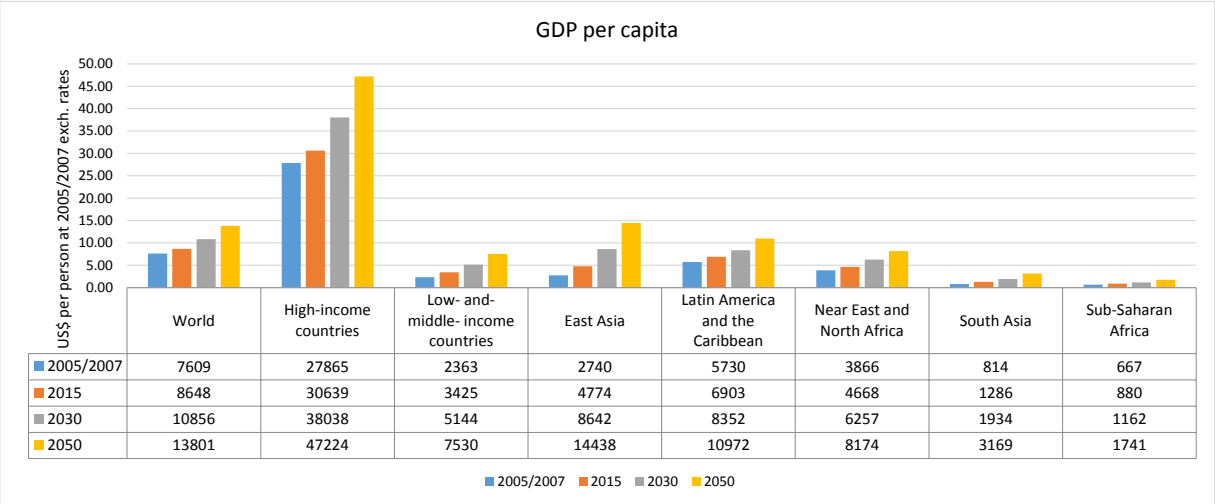


	World	High-income countries	Low- and-middle- income countries	East Asia	Latin America and the Caribbean	Near East and North Africa	South Asia	Sub-Saharan Africa
2005/2007	49,976	37,652	12,324	5,363	3,187	1,671	1,237	487
2015	62,907	42,778	20,129	10,005	4,218	2,355	2,223	803
2030	89,830	54,654	35,176	19,416	5,696	3,850	3,900	1,447
2050	125,718	67,961	57,758	32,552	7,914	5,935	7,105	2,936

Source: 2030 and 2050: AT2050. 2015: FAO Global Perspectives Studies. Unpublished data.

The conservative assumptions regarding GDP reflect on per capita GDP, leading to relatively low projections to 2050. Out of five SSPs, four project higher per capita GDP to 2050 while only one projects lower per capita GDP than the one assumed in AT2050 (Figure 3.3, black line). The global average GDP per person is projected to less than double between 2005-7 and 2050, from 7.6 to 13.8 thousand US$, exhibiting an average annual growth rate of around 1.4% (figure 3.3). This global average hides different paths in high-income and low and middle-income countries. In the latter, per capita GDP would more than triple, from 2.4 to 7.5 thousand US$, with an average annual growth rate of 2.7%. In high income countries instead, the average annual growth rate would be much lower, at around 1.2%. Despite this difference in growth, to 2050 the per capita GDP in low and middle-income countries would still be a small proportion of the per capita GDP of high income countries, i.e. only around 16%, i.e. nearly one sixth, (although bigger than the proportion in 2005-7, amounting to around 8.5%). Furthermore, the absolute difference in per capita GDP between low and middle-income and high income countries in 2005-2007 is so large that the absolute distance will continue to widen. It is projected to increase by more than 55%, from 25.5 to almost 40 thousand US$.

Figure 3.3: Long-term per capita GDP projections, by region



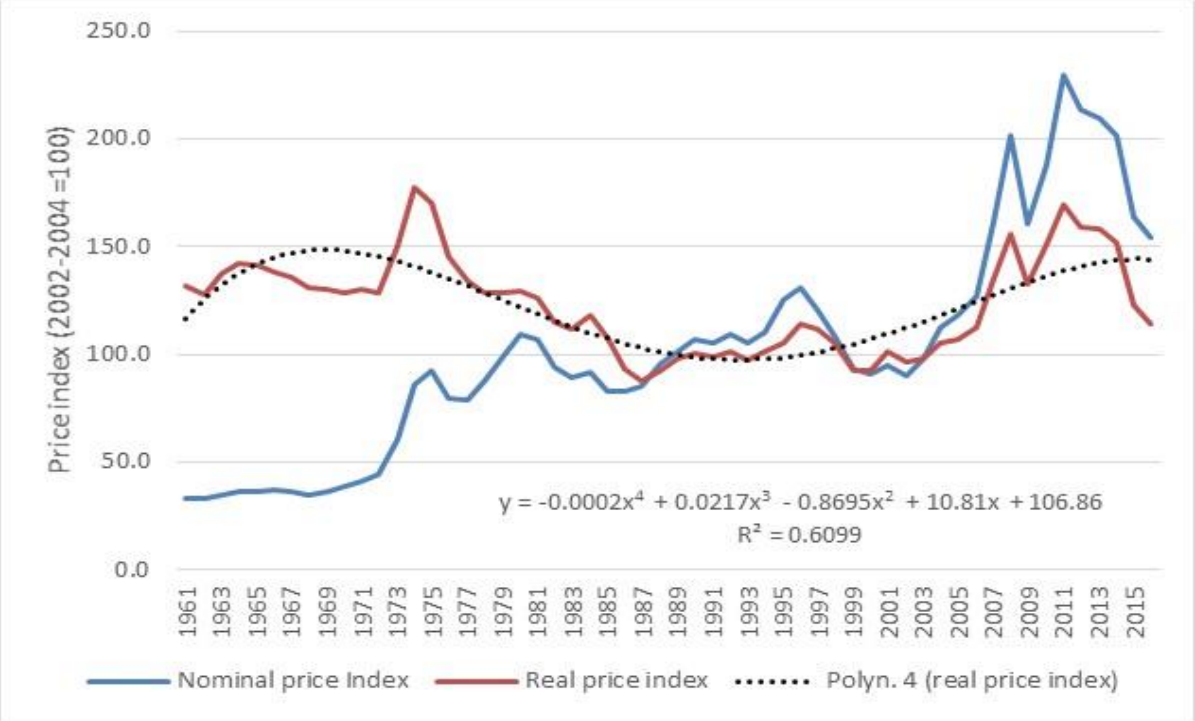
	World	High-income countries	Low- and-middle- income countries	East Asia	Latin America and the Caribbean	Near East and North Africa	South Asia	Sub-Saharan Africa
2005/2007	7609	27865	2363	2740	5730	3866	814	667
2015	8648	30639	3425	4774	6903	4668	1286	880
2030	10856	38038	5144	8642	8352	6257	1934	1162
2050	13801	47224	7530	14438	10972	8174	3169	1741

Source: Y2030 and 2050: AT2050. 2015: FAO Global Perspectives Studies. Unpublished data.

3.2 Food prices.

The real FAO food price index, is built by aggregating the international prices of a basket of five groups of food commodities, weighted with the average export shares of each of the groups for 2002-2004 and deflated with the manufactures unit value index. It shows for the last fifty years a fluctuating trend and, since its peak in 2011, it decreased to reach the current level, which is close to the levels of the eighties of the last century. Since its peak in 2011, the index is decreasing and is now close to the levels of the eighties of the last century (Figure 3.4).

Figure 3.4 FAO Nominal and Real food price Index



Source: Elaborated on FAO food price index. Accessed 20 July 2016. The real food price index is the nominal food price index deflated with the deflated with the manufactures unit value index as reported by the World Bank http://www.fao.org/worldfoodsituation/foodpricesindex/en/ .

The downward tendency may continue in the short to medium term or stabilize at levels slightly higher than the years before the 2007-08 spike, as highlighted in the FAO-OECD outlook[14].

Future levels of food prices depend on how the production will be able to accommodate the pressure of increasing demand in a resource-constrained environment and under climate change conditions. Climate change may jeopardize the possibilities to expand agricultural yields as required to accommodate expanding demand, putting an upward pressure on prices. In addition, mitigation policies may require the internalization of carbon emission costs.

Furthermore, prices in the long run might also show upward shifts, as long as there will be the need to reduce GHG emissions to comply with international agreements on climate change. The IPCC AR5 report shows that agriculture, forestry and the other sectors involved in land use changes (the so called "AFOLU sector") present economically viable opportunities to reduce GHG emissions. For instance, with carbon prices at 50 US dollars per CO_2 ton equivalent the economic mitigation potential could achieve up to 6.5 gigatonnes of CO_2 equivalent per year, i.e. around half of the total emissions of the AFOLU sector[15]. However adopting these mitigation measures will imply that additional costs will have to be afforded by the sector, leading to an upward pressure on output prices.

In any case, prices at regional level may show diverging trends due to different population growth rates, different climate change impacts as well as different possibilities to compensate net food deficits by accessing international markets. This may not only be due to logistical aspects or trade barriers, but to the capacity to import, as long as persistent trade/payment balance imbalances materialize.

3.3 Investment

The global picture of investment, as measured by the economy-wide gross fixed capital formation (GFCF), shows that it is increasing in the last 25 years (figure 3.5)[16].

Growth paths however differ across country groups. The high-income countries display an average annual growth rate from 1991 to 2014 of less than 2%. In these countries, an overall contraction of GFCF of almost 15% compared to the previous period occurred in the years 2008-09, due to the financial crisis and subsequent recession. However, in 2014, thanks to a progressive recovery, the GFCF it almost got back to the previous levels of around nine trillion US$ (constant prices 2005) per year.

In China, gross fixed capital formation dramatically increased in the last decades, from around hundred billion US$ in 1991to around 2.4 billion in 2014, at an annual growth rate of around

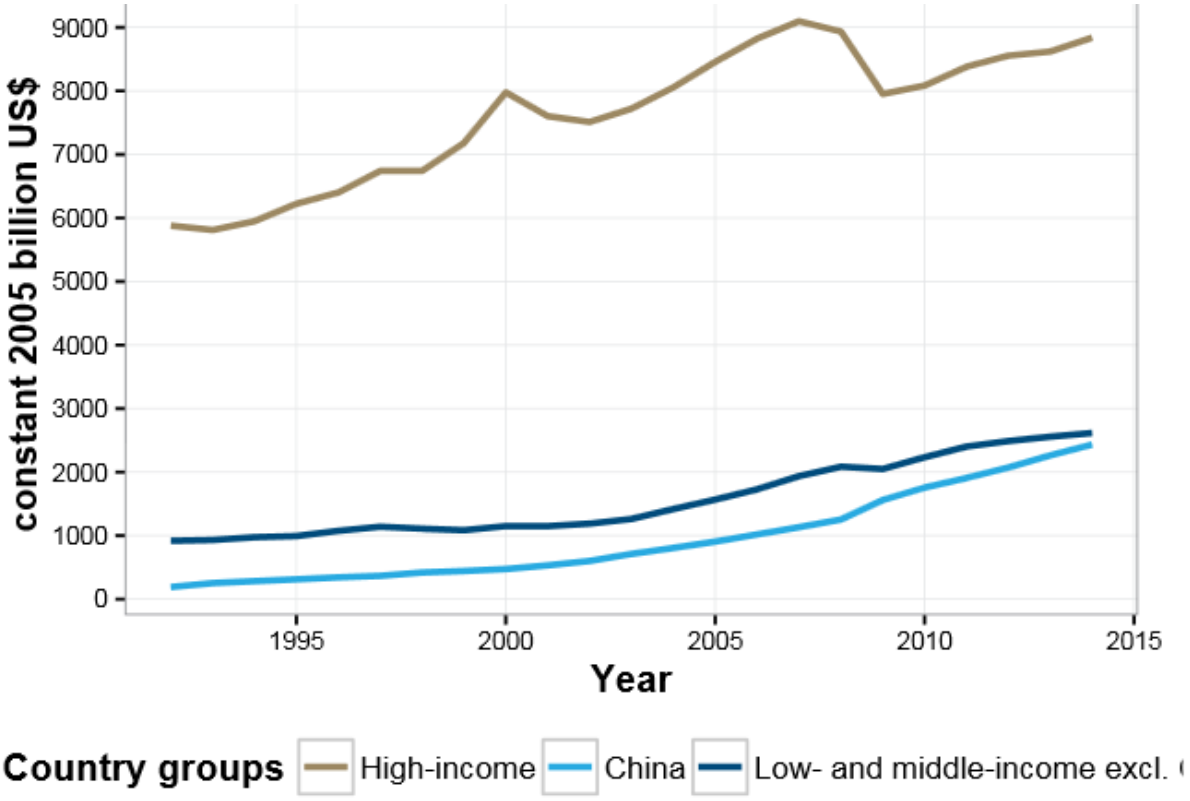
[14] OECD/FAO (2016), OECD-FAO Agricultural Outlook 2016-2025, p.52. OECD Publishing, Paris. http://dx.doi.org/10.1787/agr_outlook-2016-en

[15] IPCC, 2014. Fifth Assessment report, Chapter 11. Agriculture Forestry and other Land Use. p. 852.

[16] The gross fixed capital formation is defined in the System of National Statistics as "…the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non- produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realised by the productive activity of institutional units" https://stats.oecd.org/glossary/detail.asp?ID=1171, reflects the capacity of economic systems to use part of their product to maintain or reinforce their asset base to produce future wealth. Being "gross", by definition it does not take into consideration depreciation.

15%. The group of other (excluding China) low and middle-income countries show a lower average annual growth rate, slightly above 4%, that brings their GFCF from around 120 billion US% in 1991 to one trillion US$ in 1991 to 2.7 trillion in 2014. These different dynamics across country groups allowed to reduce their mutual gaps. However, the GFCF in 2014 in high-income countries is still almost 80% larger than the capital formation in the rest of the world[17].

Figure 3.5: Economy-wide Gross Fixed Capital Formation (GFCF), constant 2005 dollars



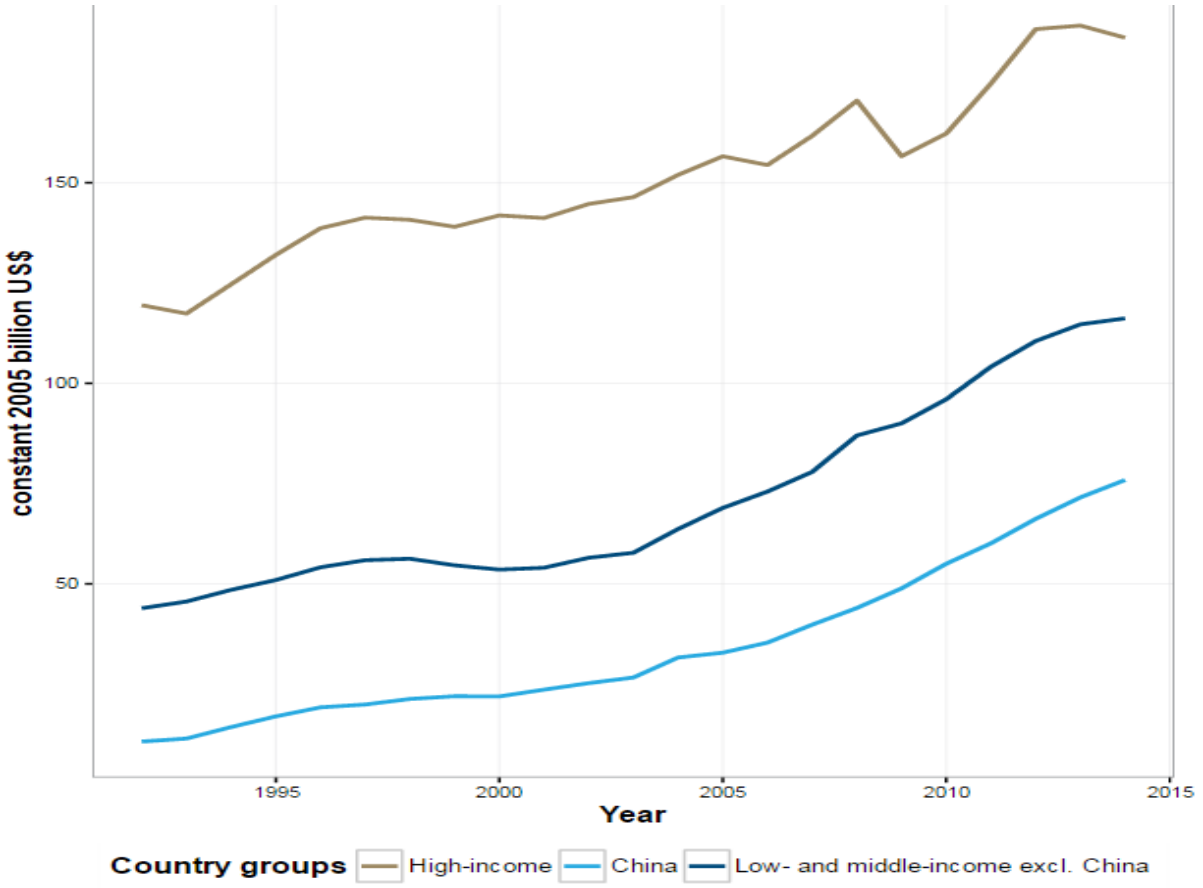
Source: FAO Global Perspectives studies, elaborated on: UN System of National Accounts (SNA) http://unstats.un.org/unsd/nationalaccount/

Regarding the GFCF in agriculture, the dynamics almost followed the economy-wide ones in all groups of countries with the exception of China. In high income countries, in the period 1991-2014, GFCF in agriculture increased from around 120 to 190 billion US$ at an annual average growth rate slightly above 2% (figure 3.6). In the rest (excluding China) of low and middle income countries the average annual growth rate in the same period was slightly above

[17] Per capita gross fixed capital formation show that the gaps across groups of countries is much wider than the gap in absolute values (see chapter 2.7).

4%. In China the GFCF in agriculture grew at an average annual growth rate only slightly above 9%, as compared to an almost 15% economy-wide growth rate.

Figure 3.6: Gross Fixed Capital Formation (GFCF) in agriculture, constant 2005 dollars



Source: FAO Global Perspectives studies, elaborated on: UN System of National Accounts (SNA) http://unstats.un.org/unsd/nationalaccount/

The annual GFCF in agriculture in high-income countries almost equals in absolute terms the GFCF in the rest of the world (slightly below the two hundred billion in both groups of countries. If recent trends in the last decade continue, in the nearest future the GFCF in agriculture in low and middle income countries could exceed the one in high income countries. A closer look to investment in agriculture in other low and middle-income countries however, reveals that, the dynamics of GFCF are led by South Asia and Europe and Central Asia, while in other continents, such as Sub-Saharan Africa, Latin America and North-Africa and Middle-East GFCF is much less dynamic.

3.4 Investment projections and investment needs to eradicate hunger.

Investment projections, both economy-wide and in agriculture, have been carried out by FAO under alternative scenarios to 2030, notably a "business as Usual" scenario and a scenario of additional investment to achieve zero hunger and extreme poverty eradication by 2030 (FAO-

IFAD-WFP, 2015)[18]. Under a "Business as Usual (BaU)" scenario to 2030, the annual average of low- and middle-income countries' gross investment in productive activities in all sectors may reach US$ 6 trillion per year, as compared to 4.6 trillion in the base year (2011) Although global data about the sectoral composition such investment is limited an attempt was made to project investment in rural areas (agriculture). Under the BaU scenario, in the period 2016-30 it may reach an annual average of around US$ 4 hundred billion, as compared to 266 in 2011 (Table 3.1, first panel, columns 1 and 2). Investment in social protection, estimated to be US$ 407 billion in the base year, may increase to an annual average of 746 billion between 2016 and 2030 (second panel, columns 1 and 2).

Table 3.1. Investment in low and middle income countries by sector, current, Business as Usual projections and additional investment for Zero Hunger

	Current Billion US$ 2013 (data for 2011)	BaU projections Billion US$ 2013 average (2016-30)	Additional ZH proj. Billion US$ 2013 average (2016-30)	Addit. Invest ZH / BaU (%)
Economy-wide Annual Investment in productive activities	4,645	6,090	195	3.2%
- Rural (agriculture)	266	398	138	34.7%
- Urban (other sectors)	4,379	5,692	57	1.0%
Annual Investment in social protection	407	746	65	8.7%
- Rural	n.a.	n.a.	40	n.a.
- Urban	n.a.	n.a.	25	n.a.
Annual Investment total	5,052	6,836	260	3.8%
- Rural	n.a.	n.a.	178	n.a.
- Urban	n.a.	n.a.	82	n.a.

Source and notes: Data on additional investment for Zero Hunger: FAO-IFAD-WFP, 2015. (AZH report). Other data: see the footnote[19].

Despite this increase in projected investment both in productive activities and social protection, and the fact that undernourishment is projected to decrease, by 2030, if no additional action is undertaken, still more than 650 million people, i.e. 8% of the population, will most likely suffer from hunger (Table 3.2) (see chapter 8 for further discussion on prevalence of hunger).

Table 3.2. Undernourishment (million people and prevalence)

	2006	2015	2030	Average 2016-2030 BaU
Undernourished people (million)	949	797	653	768
Prevalence of Undernourishment (%)***	14.4	11.0	7.9	9.3

Source: FAO-IFAD-WFP (2015). AZH report.

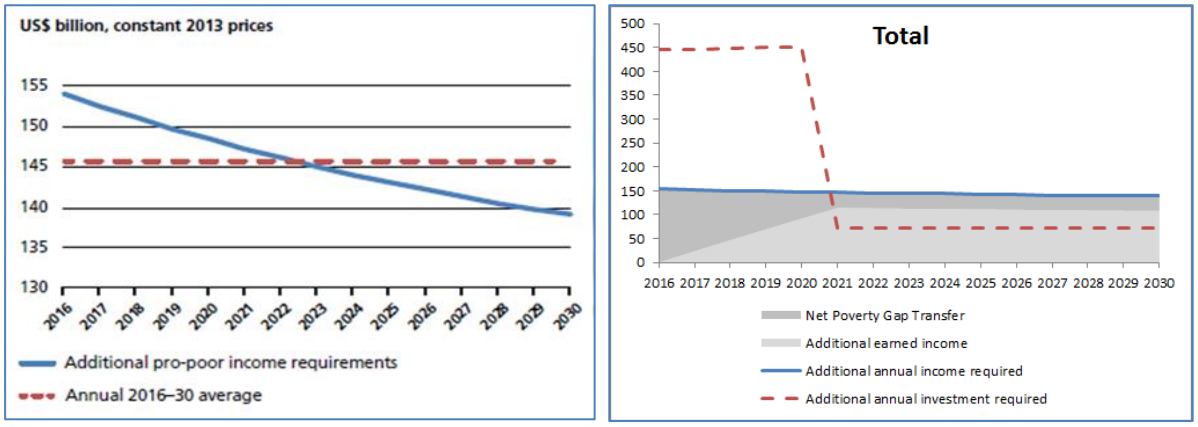
[18] FAO-IFAD-WFP, 2015. Achieving Zero Hunger: the critical role of investments in social protection and agriculture (AZH) report. FAO UN, IFAD, WFP –Rome http://www.fao.org/3/a-i4951e.pdf

[19] Annual investment in productive activities*: current (2011)* Economy-wide investment refers to gross fixed capital formation reported in World Development Indicators 2015, adjusted for outliers and missing entries. This figure is split in rural activities, assumed as referred to Agriculture: figures of investment in agriculture from FAOSTAT, (Internal ESS source); Urban investment calculated as complement to Rural. *BaU scenario*: Economy-wide and rural investment in productive activities are taken from the AZH report, tables A1.2. and A1.3, respectively. *Additional investment for ZH*: Figures from AZH report, table 4 (Urban as complement to rural).
Annual Investment in social protection: *current (2011),* source: IFPRI SPEED dataset for 2010-2011. *BaU scenario* Annual Investment in social protection BaU (2016-2030): calculated as the same proportion of GDP as in 2010-2011. *Additional investment for ZH*: Figures from AZH report, table 4 (Urban as complement to rural).

FAO, IFAD and WFP estimated that globally, additional annual investment of US$ 265 billion are needed on average to defeat extreme poverty and hunger by 2030, as compared to a "Business as usual" scenario. This amount comprises both investment in social protection programmes (US$ 67 billion) and investment in pro-poor productive activities (US$ 198 billion), i.e. activities that provide poor people opportunities to earn, save and invest. The bulk of this investment, i.e. 260 billion US$, would be required in low and milled-income countries (Table 2.1, column 3). This implies an increase of annual investment in productive activities in rural areas of broadly by 35%, compared to the business as usual situation, while Investment in social protection country-wide has to increase by around 9%. (Table 2.1, column 4).

These investments are expected to provide people currently in extreme poverty, an average of around US$ 145 billion of additional annual income needed to get them out of extreme poverty (defined at 1.25 US$ PPP + 40% buffer) and hunger by 2030 (Figure 3.7, panel a, red dashed line).

Figure 3.7 Additional income and investment to eradicate hunger by 2030



Source: FAO (2015). AZH report.

While social protection is expected to provide a great proportion of required additional income until 2020-21 (dark-grey area in Figure 2.8, panel b) additional earned income (light grey area, Figure 3.7 panel b) may progressively outpace income from social protection, thanks to significant investment in the early years of the period (red dashed line, Figure 3.7 panel b).

To achieve zero hunger, in low and middle income countries public investment in agriculture and rural areas has to significantly increase, compared to the business as usual situation. It has to increase more than proportionally with respect to the private one, as essential public goods need to be provided. The report estimates that more than 60% of additional investment needed to enhance the income of the poor in rural areas would be public. This includes public facilities, such as transport and infrastructure, services, including research and development and other services normally provided by public bodies such as land titling and tenure security.

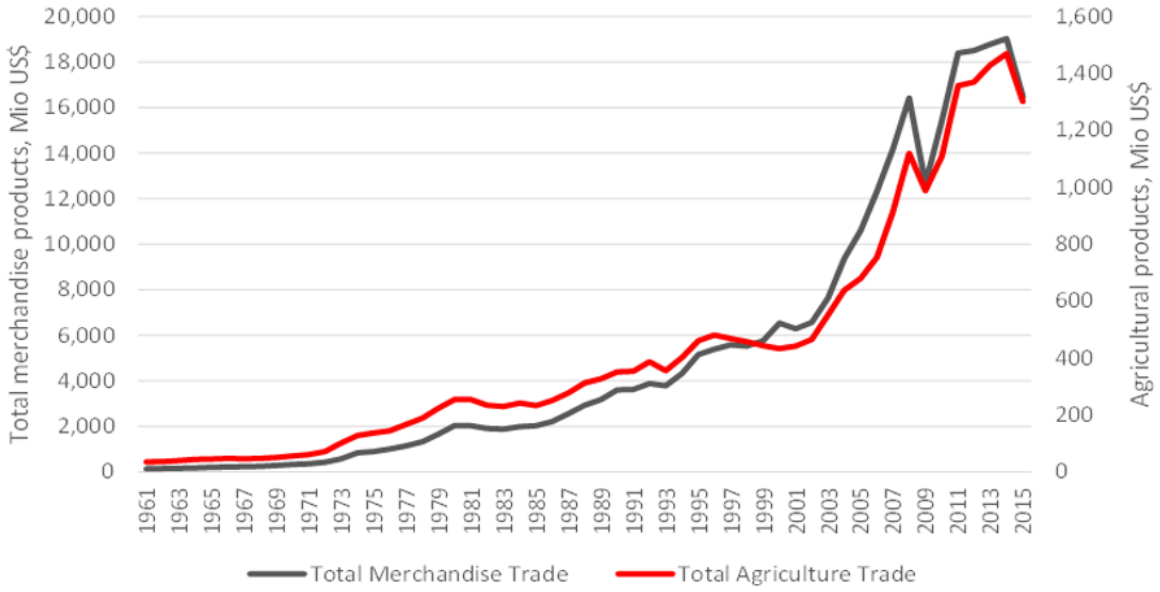
For some low-income countries with high prevalence of extreme poverty, the additional public investment for zero hunger will substantially exceed affordable amounts of public expenditure Indeed, the weak capital formation and the limited "fiscal space" implies that low-income countries would require international financial cooperation (see chapter 14).

However, international cooperation should extend to trace and stop illicit financial flows that leave low and middle income countries to the advantage of high-income countries, through various channels, such as unrecorded royalties for the exploitation of natural resources paid on foreign bank accounts, under-invoicing of exports or over-invoicing of imports within branches of the same transnational companies, bribes, etc. It is estimated that only for Africa, illicit financial flows may amount to more than 50 billion US$, with detrimental effects, not only on equity grounds, but also on economic growth potential through de-multiplicative effects and through public budget distress (UN ECA, 2012, 2015)[20].

3.5 Trade

International trade accelerated after the end of the millennium (Figure 3.8). The financial crisis of 2007/08 and the recession that ensued brought international trade growth to an abrupt end. Both overall and agricultural trade contraction lasted until 2009. In tandem with trade contraction, many OECD countries entered a recession phase. International trade volumes recovered after the global financial crisis, but growth has been sluggish since then. After a solid post-recession rebound in 2010, when the volume of international trade rose 13 percent, trade volumes grew by 6.2 percent in 2011, 2.8 percent in 2012 and 3.0 percent in 2013. These developments are now commonly referred to as the "global trade slowdown"[21]. Preliminary data for 2014 suggest that this slowdown has turned into a new contraction in 2015, which is in its extent comparable to the contraction during the great recession of 2007/08 (Figure 2.9).

Figure 3.8: International economy-wide and agricultural trade, million US dollars



Source: Data from 1961-2013 are based on FAOSTAT, those for 2014 and 2015 are based on ITC data, available on line at: http://www.trademap.org/Index.aspx

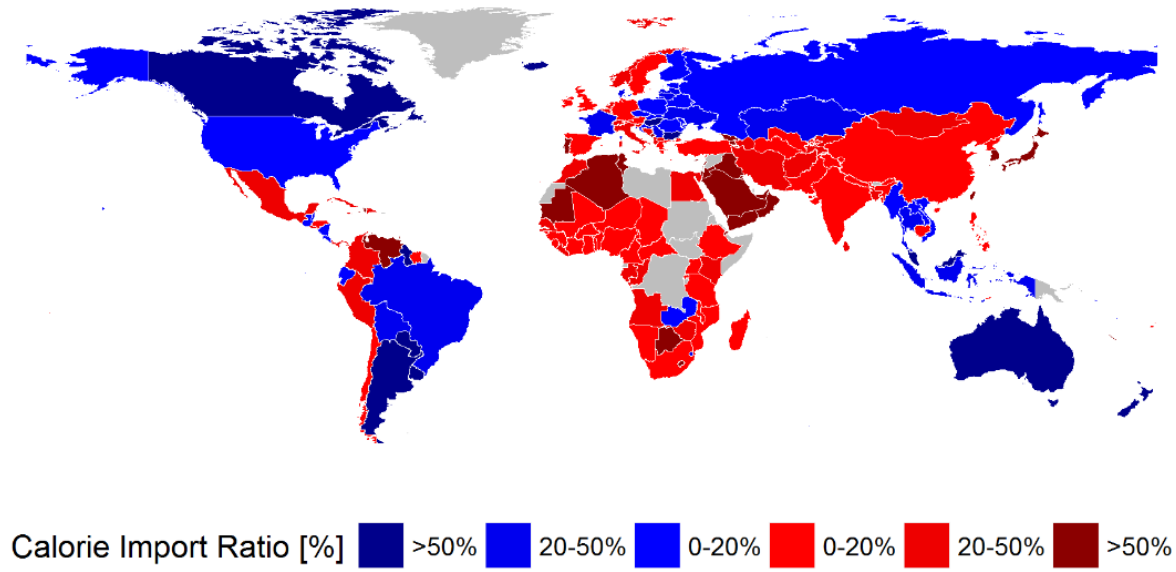
[20] UN Economic Commission for Africa (UN ECA), 2012-15. "Track it! Stop it! Get it!" Illicit Financial Flows: why Africa needs to "Track it! Stop it! Get it!
full report: http://www.uneca.org/sites/default/files/PublicationFiles/iff_main_report_26feb_en.pdf . Abridged version: http://www.uneca.org/sites/default/files/PublicationFiles/illicit_financial_flows_why_africa_needs.pdf

[21] Donnan, Shawn (2014), "OECD Warns on Global Trade Slowdown", Financial Times, 27 May 2014

Changes in international agricultural trade have moved largely in parallel with those in economy-wide international trade albeit at much lower volumes. The past 15 years have even seen faster growth in international agricultural trade, resulting in a rising share in economy-wide international trade, expanding from 6.6 percent in 2000 to almost 8 percent in 2015. But like for economy-wide trade, growth in agricultural trade has been slowing over the past years and declined sharply in 2015. The proximate factors behind this decline include a lack of progress in multi-lateral trade negotiations under the auspices of the WTO, notably the failure to conclude the DDA; a sharp decline in commodity prices across the entire agricultural spectrum; slower GDP growth and import substitution of large Asian importers; a partial relapse into protectionist policies (see e.g. World Bank data on Temporary Trade Barriers, TTBs), as well as rising energy and transportation costs.

Despite the mentioned generally fast growth of agricultural trade, it seems that food remains dominantly from domestic origins in many countries and net imports (exports) stay within the range of 0-20% of the domestic food supply in many instances (figure 3.9). However, selected countries such as United States of America, Argentina and Australia exhibit net exports of more than 50% of their domestic food supply, while other countries, specifically in the Near-East North Africa region import more than 50% of their domestic supply. Figure 3.9 also shows that Africa, South Asia and China are to a different extent net importers of food.

Figure 3.9: Net food imports (exports) as share of domestic food supply (total calories)



Source: Global Perspectives Studies (GPS) team. Preliminary analysis based on FAOSTAT 2011 food balance sheets (extraction September 2016).

Regional trade agreements[22]. Three large regional trade agreements (RTAs) have recently been concluded or are under negotiation. These are the Trans-Pacific Partnership (TPP), the Regional Comprehensive Economic Partnership (RCEP), and the Transatlantic Trade and Investment Partnership (TTIP). All three include or at least affect agriculture. They may to further liberalize agricultural trade and change rules for food safety, animal and plant health, and consistency in food product standards. These RTAs are also expected to address the rights and obligations associated with the legal protections associated with the use of names of certain foods and wines in international trade (i.e., geographical indications) and address the scope of patent protections available for plants. Additional disciplines on the use of subsidies for agricultural exports and under what circumstances agricultural export restrictions could be imposed are also on the negotiating agenda.

Levels of border protection on agricultural imports of countries negotiating these agreements range considerably, from close to zero for Australia and New Zealand to high on certain commodities imported by Japan and Canada. Except for the European Union (EU) and the United States (US), many of the other countries involved in the TPP and RCEP have already entered into bilateral FTAs that have eliminated tariffs on many commodity and food imports or are still in the process of phasing them out[23].

Some studies report that The TPP and TTIP would result in noticeable increases in agricultural trade flows among participant countries (trade creation), and show that third countries would see a fall in their exports for some commodities into these new trade blocs (trade diversion). A study by the US Department of Agriculture (USDA) estimates that such trade in 2025 among the 12 TPP partners would be 6 percent higher (+ US$8.5 billion) than it would otherwise be without an agreement. An analysis commissioned by the European Parliament (EP) projects that bilateral EU-US agricultural trade under TTIP would be 86 percent higher (+US$40 billion) in 2025. It found that addressing the restrictive trade aspects of existing SPS and TBT measures on both sides would account for more than two-thirds of this increase.

Some low-income countries fear that the tariff and/or quota elimination on agricultural products negotiated among RTA partners could erode the tariff preferences that have given their agricultural exports a competitive edge in selling into these countries. The rules of origin crafted in each of the mega-regionals could affect the extent to which agricultural commodities from third countries are utilized as inputs into each trade bloc's food processing sectors. Another fear is that strengthened TPP and TTIP regulatory disciplines and processes would institutionalize how SPS and TBT rules are applied and set the stage for more rigorous standards that third-country exporters of agricultural products might find more difficult and costly to meet.

[22] This sub-section has heavily drawn on How could Mega-Regional Trade Negotiations Affect Agricultural and Food Trade? By Remy Jurenas, September 2015. Other material used includes: From Nairobi to Confidence Building Measures in Geneva, by Crawford Falconer, December 2015 and Japanese Agriculture Trade Policy and Sustainable Development, by Kazuhito Yamashita, September 2015.

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

4 Competition for natural resources

Projections to 2050 suggest growing scarcities of agricultural land and water[24]. Although over the past decades world agriculture has become considerably more efficient, climate change is expected to exacerbate the existing challenges faced by agriculture and natural resources systems, posing challenges for forest, marine capture fisheries and biodiversity resources.

Intensification of human activities threatens natural resources. Competition over natural resources between agricultural production for food and non-food purposes is not new. However, the nature and the intensity of the competition has increased significantly in several ways during the past decade and this tendency is expected to continue in coming decades. The competition is driven by accelerated intensification of human activities such as urban expansion, infrastructure, industry, mining, food production, including in-land aquaculture, bio-energy and non-food raw materials, wood and tertiary products. This leads to increasing pressures on land, water, biodiversity, energy and nutrients. Consumption of cereals and oilseeds for the production of biofuels has increased, as well as the use of biomass as a substitute for petrochemicals.

Competition over natural resources is exacerbating pressure on and hence degradation of resources and ecosystems. At the same time, degradation and abandonment of natural resources can lead to increased competition over not yet degraded natural resources and to expansion of activities into fragile and degraded areas which then become further threatened. Scarcities of agricultural land, water, energy and nutrients vary widely geographically, with in some cases scarcity in one region due to biophysical or political and socioeconomic constraints, excessive or inappropriate use and environmental harm in other regions, and climate-induced weather changes that affect availability of natural resources, especially aquatic resources.

The emerging international trade of wood pellets is a recent trend that could impact the competition for land. This trade is currently almost entirely 'north-north', and is primarily made up of wood pellets exported from the USA and Canada to EU countries but also with an emerging trade between Russia and the EU, and Russia and East Asia. While there is concern that this expanding demand for industrial wood energy in industrialized countries will result in trade from southern to northern countries, this has not yet materialised[25]. Nonetheless, it is important to note that there have been investments made in expanding tree plantations supposedly with a view to supplying northern demand.

Another factor affecting the pressure on natural resources are input and production subsidies to the agricultural sector, such as for energy, fertilizer, water and government purchase of production (which aim to promote production and food security but may promote the expansion of agricultural lands) as well as harmful fisheries subsidies which contribute to overcapacity of global fishing fleets and results in overfishing.

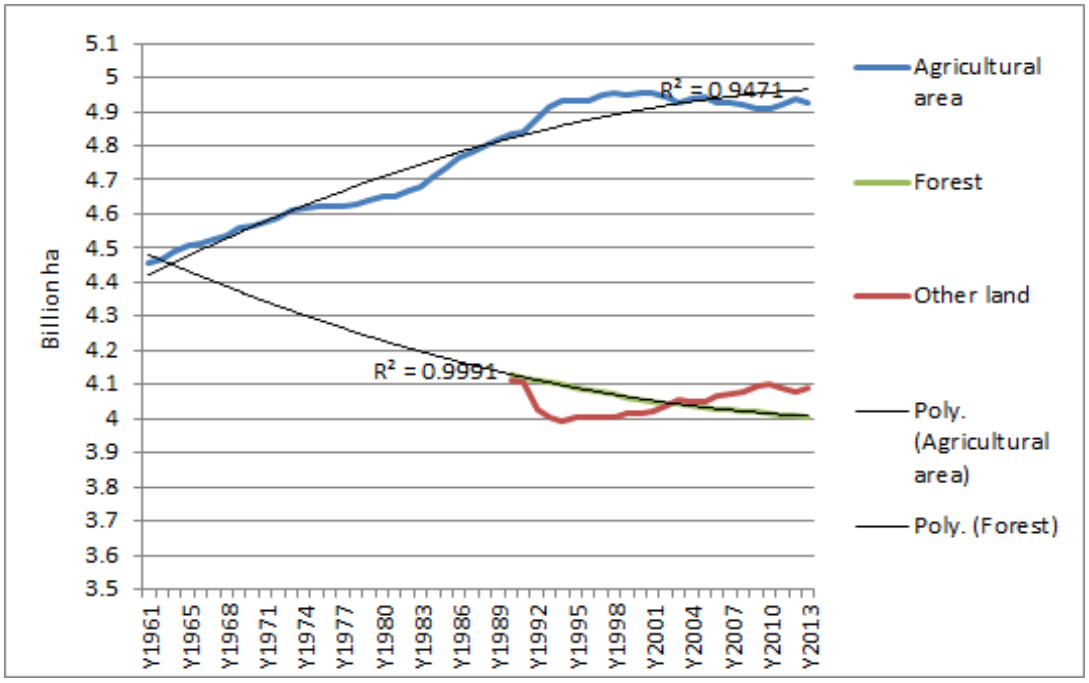
However, globally the expansion of land for agricultural purposes has stabilized in the last twenty years at around 4.9 billion hectares, while forests lost less than 0.1 billion hectares, (Figure 4.1). Projections of additional land requirements to 2050 from AT2050 highlight the

[24] AT2050

[25] For instance, the exports of woodfuels from the western Balkans increased by 5.8% in 2015 compared with 2014. UNECE/FAO (2016), Forest Products Annual Market Review, 2015-2016

need of less than 0.1 billion hectares. This may give the impression that no land constraints will arise in the future. Nevertheless, the global picture hides regional differences: for example, while globally, annual forest losses decreased to 4 million ha/year between 2000 and 2010, in the tropical and subtropical regions of the world the losses still amount to 7 million ha/year while, in the same period, agricultural area expanded by 6 million ha/year (SOFO 2016, FAO). In addition, in many parts of the world additional land is not readily accessible, due to lack of infrastructures, remoteness and disconnection from markets or located in disease-prone areas. Furthermore, available land is also concentrated in few countries.

Figure 4.1 Trends in land use, 1961-2013



Source: FAO Global Perspectives Studies calculations based on FAOSTAT data (accessed: May 2016).

4.1 Bioenergy and competing land uses

Bioenergy is increasingly important, but poses environmental concerns if not properly managed. Globally, around 13.8% of all energy used comes from renewable sources, of which 72.8% from bioenergy. This includes liquid transportation fuels and the combustion of municipal solid waste and woodfuels[26]. In total, around two thirds of that bioenergy use involves traditional use of wood and other biomass for cooking and heating, as is practiced by much of the population in low-income countries. These traditional uses may grow as population grows. There are risks related to bioenergy and bioenergy production regarding natural resources management and food security. Much of this traditional wood energy is unsustainably produced and inefficiently used, affecting food security and health of poor populations and leading to environmental degradation.

Recent work, including by FAO, shows that good practices allow to produce both food and bioenergy (including biofuels) in a sustainable way, generating a growing interest in bio-

[26] Ref: Key Renewables Trends – 2016
http://www.iea.org/publications/freepublications/publication/KeyRenewablesTrends.pdf

economy**,** i.e. the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy, worldwide**.**

Good practices include agro-ecological zoning, complementing the production of food with bioenergy generation through sustainable agriculture intensification, and developing integrated food-energy systems through either land use optimization (e.g. mixed food and energy crop systems) or biomass use optimization (e.g. biogas from livestock manure).

Bioenergy demand for electricity generation is an area where projected demand is expected to grow by 50% between 2013 and 2020 (IEA, 2015), and bioenergy for building heating purposes will also be growing by approximately 25% over the same time period.

Similarly, there has been a significant increase in the amount of biofuels produced, from around 60 billion litres in 2007 to around 130 billion liters in 2015, projected to grow to 140 billionliters in 2020 (IEA, 2015), with a significant impact on the consumption of food/feed crops.

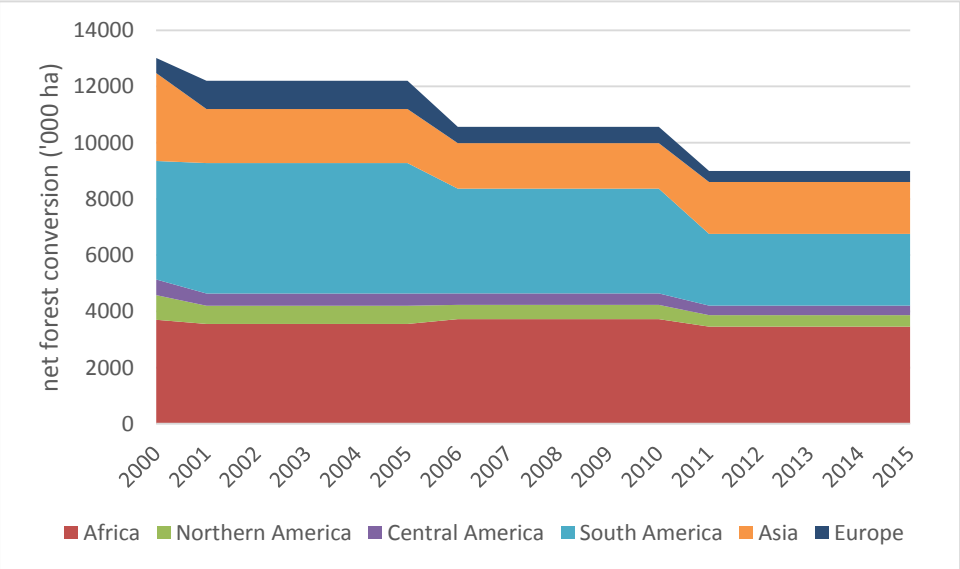
For instance, between 2000 and 2011 the annual growth rate of world's cereal consumption was 1.8 percent. If the consumption of cereals for biofuel production in the United States of America is not considered, this growth would drop to 1.3%. An increased use of vegetable oil for biofuel production was also observed. For instance, between 2000 and 2009, the consumption of vegetable oil for all purposes grew at an annual rate of 5.1%, while the consumption of vegetable oil for bio-fuel production grew at an annual rate of 23% (HLPE, 2011)[27]. Biofuel production is expected to consume 10.5% and 13% of global coarse grains and vegetable oil production respectively in 2024. By 2024, 25% of global sugarcane production is used to produce ethanol, up from 21% in 2014 (OECD-FAO, 2015)[28]. The competing land uses described above have led to a considerable conversion of forest areas into other uses.

This trend could lead to increased competition between food and non-food uses of biomass, increasing interdependence of food, feed and energy markets. It can also impact negatively on local food security and access to land resources. For example, oil seeds are becoming a larger component of fish feed for aquaculture. Aquaculture, which now provides more than 50% of all fish consumed is expected to intensity and so will the demand of oil seeds as fish feed.

However, the net forest conversion has been decreasing over the last 15 years (Figure 3.4) and the annual losses have been reduced by 50% since 1990 (FAO, 2015)[29], with significant regional differences and increases and decreases in some countries. While in the last fifteen years in Europe and Americas forest losses have been diminishing, in Africa and Asia they continue almost at the same pace. Furthermore there is evidence that it is possible to reconcile food security achievements and forest preservation. FAO's State of the World's Forests 2016 identified 22 countries that have improved agricultural production and food security in the past twenty-five years while maintaining or increasing their forest cover (FAO, 2016)[30]. Much of this is due to the simultaneous implementation of policies promoting the intensification of agricultural production, sustainable management of forest resources and other measures to improve food security.

[27] HLPE, 2011. Price volatility and food security. A report by the high level panel of experts, pp 32-33 CFS- Rome
[28] Source: OECD-FAO (2015), Agricultural Outlook 2015-2024 http://www.fao.org/fileadmin/templates/est/COMM_MARKETS_MONITORING/Oilcrops/Documents/OECD_Reports/OECD_biofuels2015_2024.pdf
[29] FAO, 2015. Global Forest Resources Assessment. http://www.fao.org/3/a-i4808e.pdf
[30] FAO, 2016. State of world's forests: Forests and agriculture: land use challenges and opportunities. Rome, p.54

Figure 4.2 Net forests conversion (loss of forested area)



Source: FAOSTAT

The overall impact of increasing demands for food and fuel, will depend on productivity improvements in the agricultural sector, and also other known good practices in sustainable bioenergy[31]. While this includes expectations of improved feed conversion ratios in aquaculture, this will likely be somewhat offset by greater reliance on feeds to maximise production per unit land and water use (Troell et al. 2014)[32]. However, agricultural intensification may cause more rather than less cropland expansion depending on the elasticity of supply of land, and the extent to which intensification is labour or capital intensive. Mitigating climate change by mandating the use of biofuels in one place may increase global greenhouse gas emissions due to indirect land use changes in remote locations (Lambin and Meyfroidt, 2011)[33].

The risks and opportunities associated with increased bioenergy production and use will be expanded by the increasing interest in bio-economy – i.e. an economy based on bio-based goods) worldwide, given that this means additional production of bio-products. Indeed, the World Economic Forum estimates that the revenue potential for new business opportunities in the biomass value chains could globally amount to about USD 295 billion by 2020; that is three times the amount of 2010 (WEF, 2010).[34] A key reason for the interest in bio-economy lies in the need to decouple economic development from the use of fossil fuels to address climate change. Given the importance and challenges of sustainable bio-economy development and its transformative role of the agriculture, forestry and fisheries sectors, at the GFFA 20015

[31] In 2015, 0.6 hectares of forests per person were used to sustain demands for food, land and fuel (FAO FRA 2015).

[32] Troell, M, Naylor, R, Metian, M, Beveridge, M, Tyedmers, P, Folke, C, Österblom, H, de Zeeuw, A, Scheffer, M, Nyborg, K, Barrett, S, Crépin, A-S, Ehrlich, P, Lewin, S, Xepapadeas, T, Polasky, S, Arrow, K, Gren, Å, Kautsky, N, Mäler, K-G, Taylor, S & Walker, B. 2014. Does aquaculture add resilience to the global food system? *Proceedings of the National Academy of Sciences* 111, 13,257-13,263

[33] Lambin and Meyfroidt, 2011. Global land use change, economic globalization and the looming land scarcity *Proceedings of the National Academy of Sciences 108, 9*, 3465–3472 http://www.pnas.org/content/108/9/3465.full

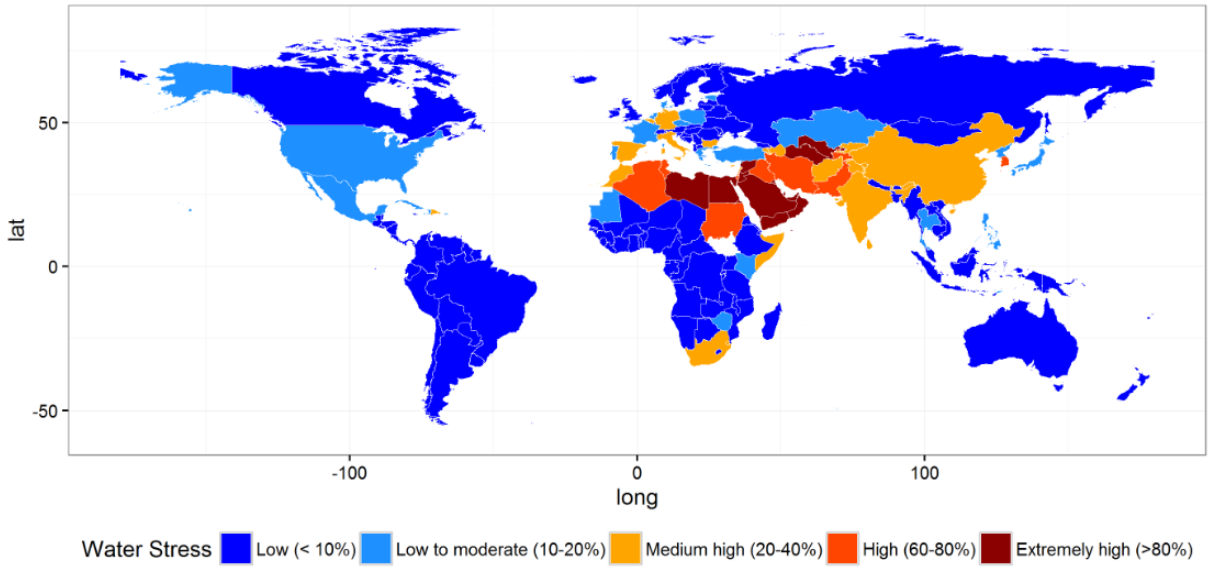
[34] WEF, 2010. The Future of Industrial Biorefineries (see: www3.weforum.org/docs/WEF_FutureIndustrialBiorefineries_Report_2010.pdf).

meeting, FAO was given the mandate to coordinate international work on 'food first' bio-economy.[35]

4.2 Water resources

Availability and use of water resources varies widely across regions. W*ater stress* can be expressed by relating the total annual water withdrawals (municipal, industrial, and agricultural) to the total annual available flow. Higher values indicate more competition among users (Figure 3.5). Many of the low rainfall areas of the Middle East, Northern Africa, India and North-East China) already use much of the exploitable water resources, leading to a serious depletion of rivers and aquifers. Globally, about 80 percent of the water is used for agricultural purposes.

Figure 4.3 Fresh water withdrawal as percent of total water resources (most recent data).

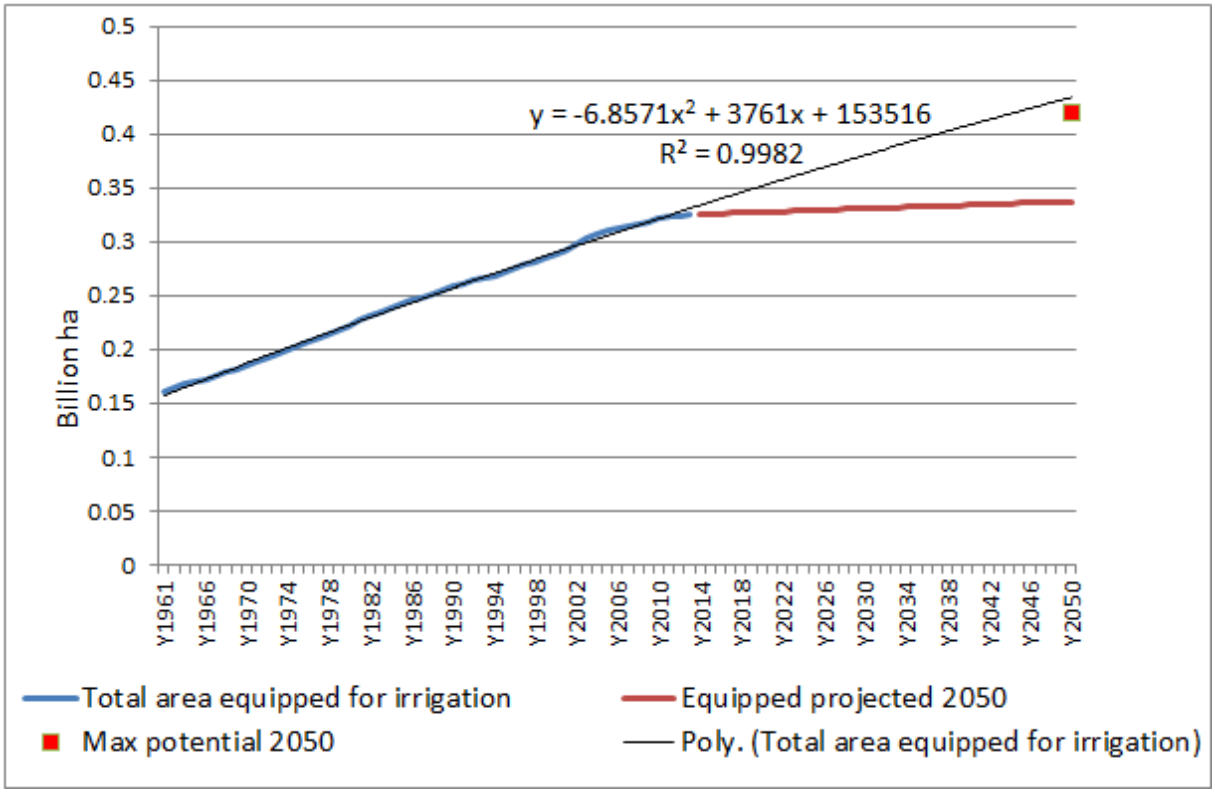


Source: FAO Global Perspectives Studies, based on FAO AQUASTAT (download October 2016) 2013.

Water availability for agriculture will become a growing constraint in areas that use a high proportion of their water resources, exposing systems to high environmental and social stress and limiting the potential for expanding irrigated areas In fact, rate of expansion of land under irrigation is already slowing substantially. FAO has projected that the global area equipped for irrigation may increase at a relatively modest rate to reach 318 million hectares in 2050, compared to around 301 million hectares in 2009 (Figure 4.4). Most of this expansion is projected to take place in low-income countries. This would represent an increase of around 11 percent, or 0.24 percent per year, much slower than in recent years – between 1961 and 2009 irrigated area worldwide grew at 1.6 percent a year and at more than 2 percent in poorest countries.

[35] Final Communique of GFFA 2015. http://www.gffa-berlin.de/wp-content/uploads/2015/11/GFFA_communiqué_2015.pdf

Figure 4.4 Land equipped for irrigation: recent trends and projections to 2050



Sources: Years 1961-2013: FAOSTAT. Annual growth rate of projections 2014-2050 (0.1%) and max potential to 2050: AT2050

The trend in agricultural water use is also slowing down as the performance of irrigation systems and agronomy improve, raising both the productivity of irrigated land and water productivity. But rapid transitions from rural to urban settings are further spatially concentrating demand. Since agriculture will continue to be the main water user, improved agricultural water use in irrigated agriculture will have a direct impact on local and regional water demands. Allocations of raw water away from agriculture to other higher utility uses – municipal supplies, environmental requirements and hydropower generation – are already taking place, but there is still scope for optimizing these allocations in economic and environmental terms. Non-competing uses of water will become more important such as increasing the use in agriculture of treated wastewater from the urban sector.

Future water stress will not only be driven by changes in the demand but also by changes in the availability of water resources, resulting from changes in precipitation and temperature driven by climate change.

5 Climate Change[36]

The Paris Agreement, adopted at the twenty-first Conference of Parties (COP21) in December 2015, recognizes "the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse effects of climate change"[37].

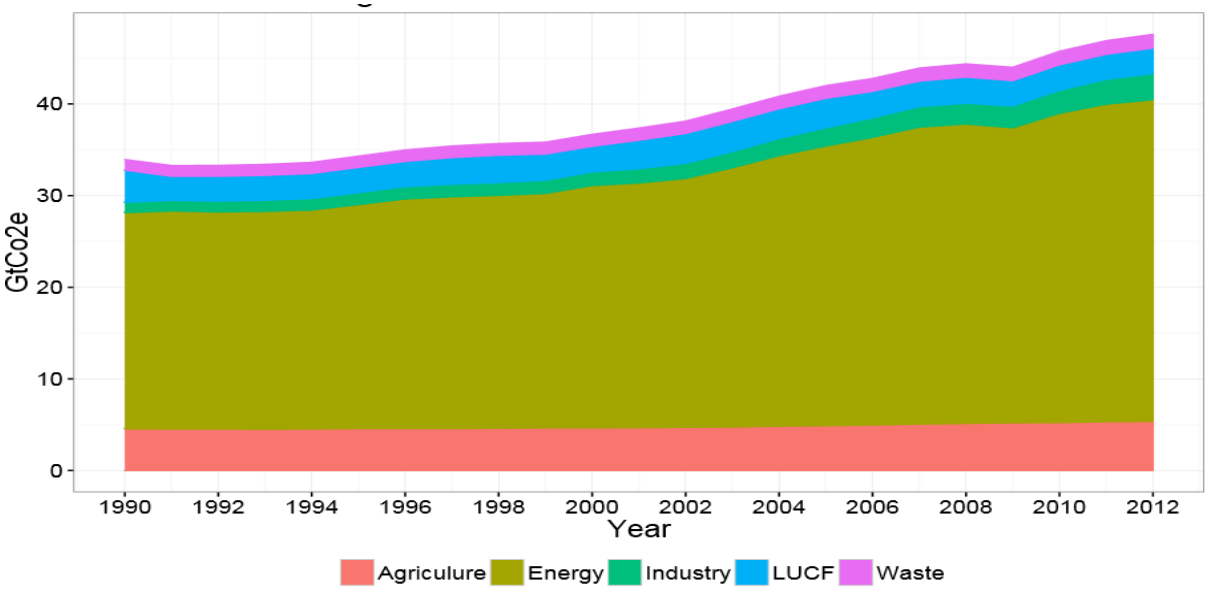
It is now well recognized that climate change, irrespective of its cause, have affected natural and human systems all over the globe. Extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human-induced influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events. Changes observed in recent decades are just an anticipation of what is likely going to occur in the next years. For instance, the surface temperature is projected to rise over the 21st century, it is very likely that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The oceans are expected to keep warming up and acidifying, and global mean sea level to rise (IPCC, 2014)[38]

The importance of land use, land use change and forestry (LULUCF) in addressing climate change is recognized and has been reaffirmed in the Paris Agreement. The recognition of the role of LULUCF has led to the launching of REDD+ by UNFCCC in 2008 to provide positive incentives to low-income countries for results-based climate change mitigation actions in the forest sector, specifically the reduction of deforestation and forest degradation, and forest conservation, sustainable management of forests and enhancement of forest carbon stocks (e.g. through afforestation, reforestation and forest restoration). Forests feature prominently in the Paris Agreement. Article 5 recognizes the central role of forests in limiting the increase in global temperature to no more than 2°C through mitigation options covered by REDD+. Forest-based mitigation actions are referred to in most countries' Intended Nationally Determined Contributions (INDCs) that were submitted to UNFCCC as a basis for the Paris Agreement. Forest adaptation actions are also included in most low and middle income countries' INDCs. The Paris Agreement also makes reference to joint mitigation and adaptation efforts in the forest sector.

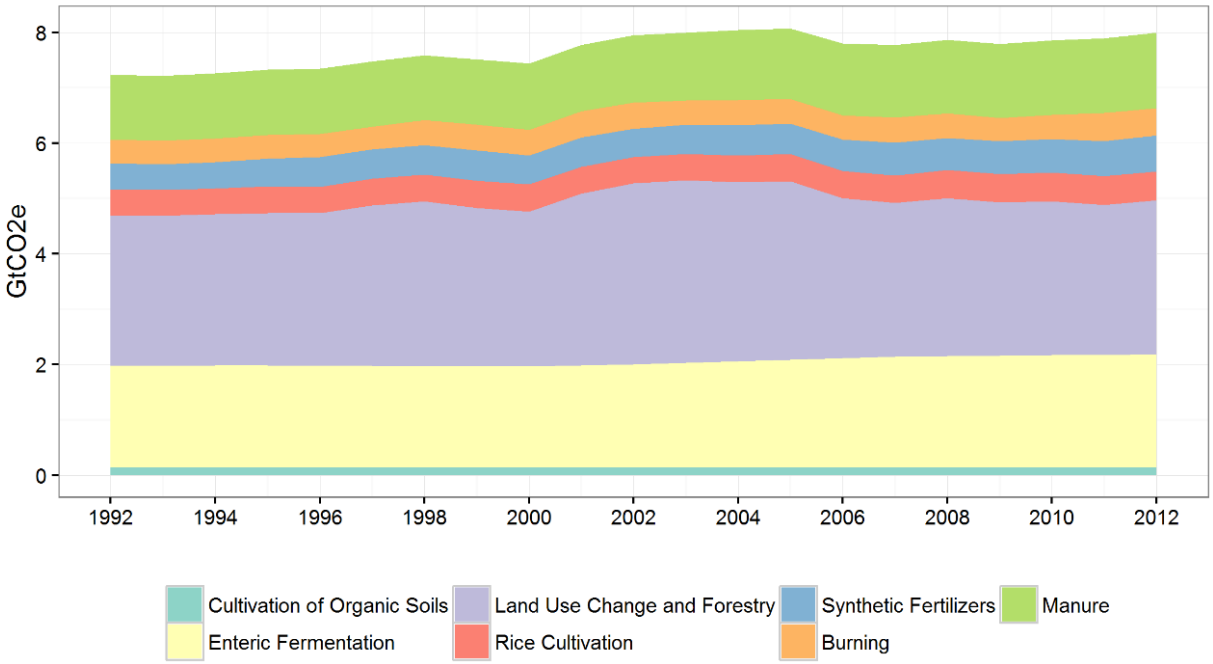
[36] This section heavily refers to and borrows from the IPCC AR5.
[37] UNFCCC, 2015. Conference of the Parties, twenty-first session: adoption of the Paris agreement https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf
[38] IPCC, 2014. Synthesis report, Summary for policy makers. http://ar5-syr.ipcc.ch/topic_summary.php

Figure 5.1 Average annual GHG emission

Panel a: All sectors



Panel b: Agriculture, forestry and land use change (AFOLU) (excluding energy)



Sources: Figure 3a: CAIT, Climate Data Explorer, Washington, DC: World Resources Institute. http://cait.wri.org. (Accessed on October 2016). Data for Agriculture and Land Use Change and Forestry in CAIT are from FAOSTAT Emissions Database. Figure 3b: FAOSTAT Emissions Database. http://faostat3.fao.org/download/G1/*/E (accessed on October 2016)[39].

[39] The classification of items in panel b is according to FAOSTAT, 2016. Manure category contains 'Manure left on Pasture', 'Manure Management' and 'Manure applied to Soils'; Burning category contains 'Burning -Crop residues', 'Burning – Savanna' and 'Crop Residues'.

On the one hand, Agriculture, Forestry and other Land Use (AFOLU) sector, substantially contributes to global anthropogenic GHG emissions. Emissions from AFOLU, expressed in Carbon Dioxide equivalent (CO_2 eq), equaled, in 2012 8 Giga Tons (Gt) (Figure 5.1b), 17% of total global anthropogenic GHG emissions in 2012 (47 giga tons, as per in figure 5.1a). If we add to this data the emissions produced by the energy employed in primary agriculture (e.g. fuel for tractors) and not accounted in AFOLU classification, the value rises to 8.9 Gt and the share of AFOLU+Energy on the total anthropogenic CO2 emissions increases to 18.7%. Furthermore, if GHG emissions in processing, trade and consumption of food, estimated to be around 3.4 giga-tons, are also considered, the total amount of GHG emissions would amount to 12.3 gigatons, say around 26% of total GHG emissions[40].

On the other hand, agriculture is affected by GHG emissions and climate change. The growing understanding of the important impacts on agriculture, and its role in addressing climate change, has been emphasised in the IPCC's Working Group II on Impacts, Adaptation and Vulnerability. IPCC dedicated a whole chapter to Food Security and Food Production Systems in the 5th Assessment report (AR5) as opposed to these issues being subsumed more generally under a chapter on Food, Fibre, and Forest Products as was the case in AR4[41]. Here below some excerpts are reported to summarize the main findings and the related degree of confidence across the community of experts.

"The effects of climate change on crop and terrestrial food production are evident in several regions of the world (high confidence). *Negative impacts of climate trends have been more common than positive ones, although positive trends are evident in some high latitude regions (high confidence). Since AR4, there have been several periods of rapid food and cereal price increases following climate extremes in key producing regions, indicating a sensitivity of current markets to climate extremes, among other factors. Several of these climate extremes were made more likely as the result of anthropogenic emissions (medium confidence). Climate change will also increase progressively the inter-annual variability of crop yields in many regions (medium confidence).*

Climate trends are affecting the abundance and distribution of harvested aquatic species, both freshwater and marine, and aquaculture production systems in different parts of the world. *These are expected to continue with negative impacts on nutrition and food security for especially vulnerable people, particularly in some tropical developing countries, but with benefits in other regions that become more favorable for aquatic food production (medium confidence).*

Studies have documented a large negative sensitivity of crop yields to extreme daytime temperatures around 30°C. *These sensitivities have been identified for several crops and regions and exist throughout the growing season (high confidence). Several studies report that temperature trends are important for determining both past and future impacts of climate change on crop yields at sub-continental to global scales (medium confidence). At scales of individual countries or smaller, precipitation projections remain important but uncertain factors for assessing future impacts (high confidence)*

[40] FAO, 2011: Energy Smart Food for People and Climate – Issue Paper - http://www.fao.org/docrep/014/i2454e/i2454e00.pdf

[41] Chapters in AR5 are also devoted to freshwater resources, terrestrial and inland water systems, coastal and ocean systems; reducing vulnerabilities and increasing resilience and adaptation in all these ecosystem will have benefits to food security and rural livelihoods.

Changes in climate and CO_2 concentration will enhance the distribution and increase the competitiveness of agronomically important and invasive weeds (medium confidence). *Rising CO_2 may reduce the effectiveness of some herbicides (low confidence). The effects of climate change on disease pressure on food crops are uncertain, with evidence pointing to changed geographical ranges of pests and diseases but less certain changes in disease intensity (low confidence)."* (IPCC, 2013)[42].

Recent FAO studies on the impact of climate shocks on smallholder agriculture in sub-Saharan Africa found that yields rise significantly with more rainfall in most cases, but suffer when rainfall is below-average and more variable; likewise, above-average temperatures reduce productivity significantly. Context-specific climatic conditions will influence smallholders' choice of adaptation measures to improve their livelihoods. The application of mineral fertilizer may generate higher yields under average climatic conditions, but lower yields under conditions of high rainfall variability or the delayed onset of rainfall; crop rotation may produce lower yields under average climatic conditions, but higher yields and a lower probability of yield loss under conditions of high rainfall variability (Arslan et al., 2015). Such variations in yield responses, both in levels and variability, are highly likely to result in lower projections of yield when taken into account, given changes in climate variability and increasing mean temperatures, but knowledge on these nuances for many contexts remain limited in this domain.

There are also important knowledge gaps on impacts of climate change on weeds, pests, and diseases, including animal diseases. Studies on adaptation of cropping systems typically only assess relatively minor agronomic management changes under future climate conditions, but adaptation to extremes is also crucial. This is an area not properly addressed so far. Forthcoming studies should examine the impact of proposed adaptations when employed in the current climate. In this way management changes that are beneficial in a range of environments can be separated from management changes that are specifically targeted at climate change. Further, studies should be inclusive of the broader range of systemic and transformational adaptation options open to agriculture. In addition Transformational adaptation options should also look at the broader multi-sectoral perspectives (IPCC, 2014).

Technical and operational convergence between climate change adaptation and disaster risk reduction (DRR) is crucial to better channelize the efforts of responding to climate change at the local level. Operationally, though these two fields of work focuses on different timeframes, convergence of on the ground actions are evident. Better coordination of efforts would enhance the effectiveness of adaptation measures. Efforts are on, but enhanced operational cohesiveness is needed to avoid duplication.

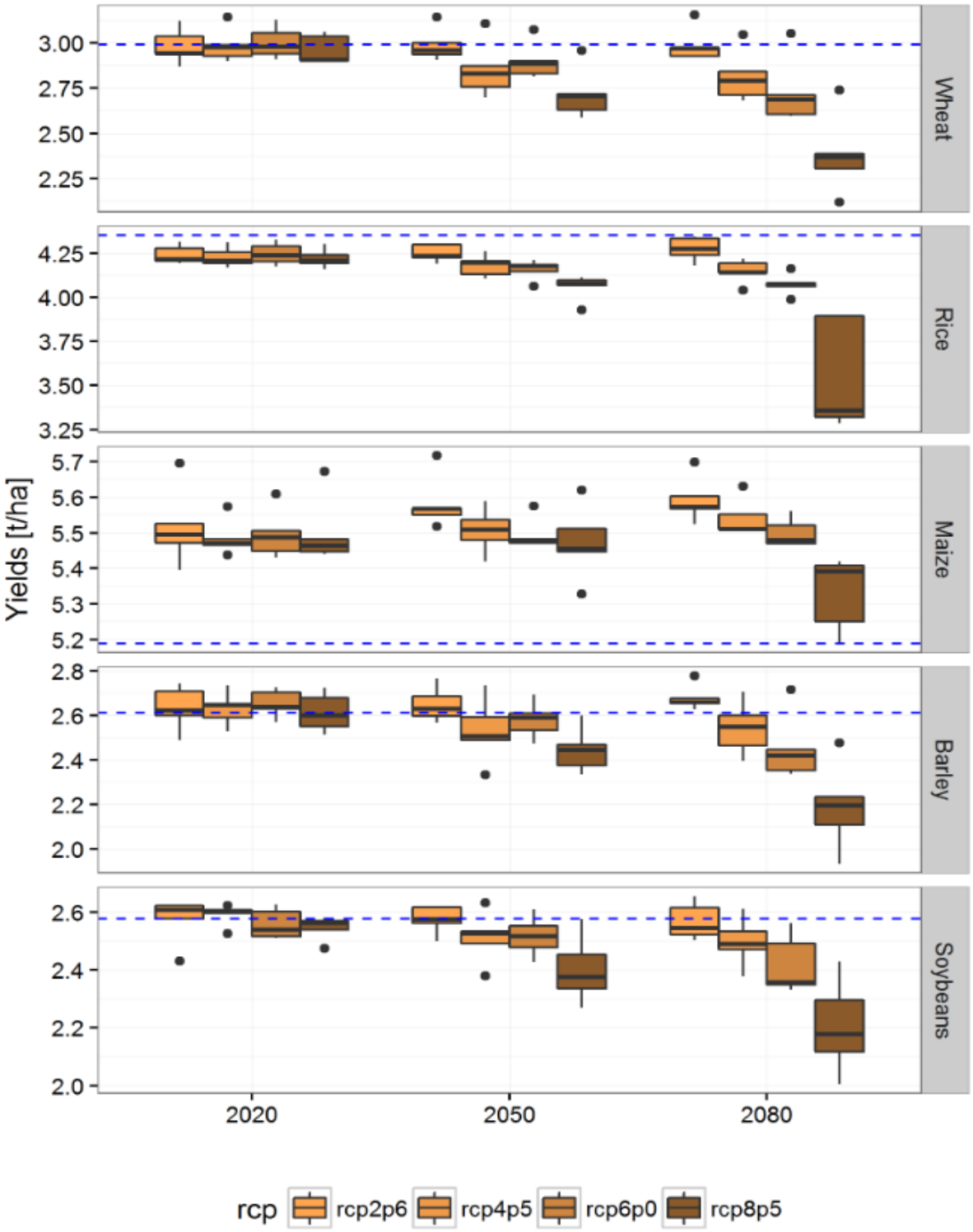
Current forecasts of changes in distribution and productivity of marine fish species and communities are typically at a global or regional scale and include adaptations to only a limited extent, mostly for the most commercially valuable species on the areas beyond national borders (ABNJs). Increasing the resolution to forecast impacts and changes at the national and local

[42] IPCC, 2014. Porter, J.R., L. Xie, A.J. Challinor, K. Cochrane, S.M. Howden, M.M. Iqbal, D.B. Lobell, and M.I. Travasso, 2014: Food security and food production systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Executive summary pp.488-489
http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap7_FINAL.pdf

ecosystem scale would provide valuable information to governments and stakeholders and enable them to prepare more effectively for expected impacts on food production and security offered by capture fisheries and aquaculture.

Combining the use of climate models (global Circulation Models- GCM) with Crop models allow gaining some insights into possible impacts of climate change on yields. For instance, for the main cereals, projected variations in yields, due to climate change under the different RCPs, show significant global shifts, mostly downwards from 2050 onward (Figure 5.2). Global (average) shifts in addition hide significant implications across areas and countries for local food and nutrition security, as well as for trade.

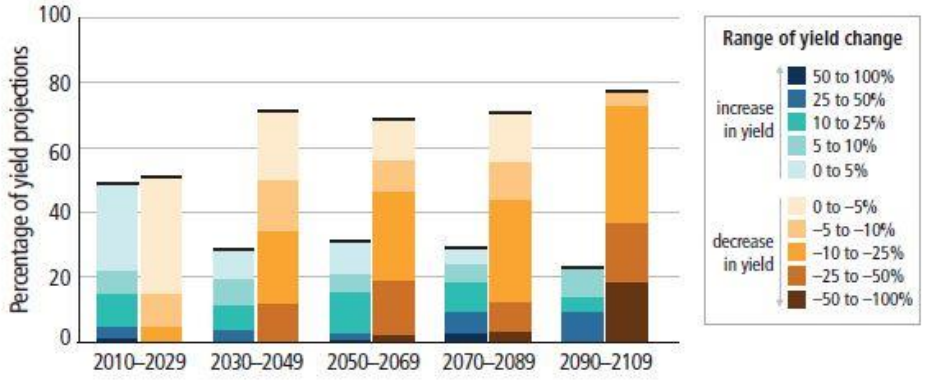
Figure 5.2 Changes in selected crop yields in 2075-84 as compared to 2006-2015



Sources and notes: Simulated yields for 5 crops under different emission scenarios (rcps), averaged for 3 ten year periods, centered around 2020, 2050, and 2080. Yield is weighted by current harvested area and calculated according to the NPP estimate of Zhang (1995), without considering CO2 fertilization effects. The dashed blue line indicates current (year 2010) yields, taken from FAOSTAT production statistics. Preliminary estimates susceptible of adjustments.

The aggregation of 1,090 studies on yields under different climate change conditions, i.e. different Representative Concentration Pathways, mostly carried out on wheat, maize, rice and soybeans, signal that climate change may significantly reduce yields in the long run (Figure 5.3).

Figure 5.3 Yield changes under climate change



Source IPCC, 2014 Chapter 7: p 504

Finer investigations on the possible impacts of climate change on agricultural production through the effects of changes in temperature, rainfall, humidity and other factors under different climate scenarios, could be eased once the new version 4.0 of the FAO-IIASA Global Agro-Ecological Zones will be released[43].

This will also enable a better understanding of implications of climate change for food security.

In summary, there are very significant knowledge gaps related to impacts of climate change on food systems. Many studies either do not examine yield variability or do not report it. Closer attention should be paid to yield variability in the quantity and quality of food production, especially given observed price fluctuations associated with climate events and the trespassing of environmental thresholds, such as high temperatures, droughts, and floods, which IPCC expects to become more important in the future.

5.1 Impacts of climate change on food security

Climate change already affects agriculture and food security, and, without urgent action, will put millions of people at risk of hunger and poverty [44]. Investigations carried out so far, reported in the fifth assessment report (AR5) of the International Panel on Climate Change

[43] "*New climate model projections, the Representative Concentration Pathways (RCP), developed for the IPCC Fifth Assessment Report and beyond, are replacing/complementing the SRES-based climate scenario on which GAEZ version 3 is based. The new projections will provide input to agro-climatic resources inventories and crop potential assessments for the 2020s, 2050s, and 2080s. … The update entails work with FAO staff to establish an operational GAEZ capacity at FAO Headquarters in Rome. The update of the IIASA/FAO GAEZ data portal was part of this work. All GAEZ-related research was co-funded by the FAO. GAEZ v4.0 also provides estimates of apparent yield and production gaps by comparing simulated potential attainable yields and production (using average climate of 30-year period 1981-2010) and actual yields and production estimated by downscaling of year 2009-11 statistics of main food and fibre crops*".
http://www.iiasa.ac.at/web/scientificUpdate/2013/researchProgram/Water/GAEZ.html

[44] FAO, 2016. The state of food and agriculture. Climate change, agriculture and food security.

(IPCC), highlight that impacts of climate change on all the dimensions of food security are likely to be negative, particularly if adaptation capacities do not materialize and/or global temperature increases of or more than 4°C above the end of the last century. Here below some excerpts from AR5 summarize the main findings and the related degree of confidence across the community of experts regarding the impacts of climate change on food security:

"All aspects of food security are potentially affected by climate change, including food access, utilization, and price stability (high confidence). *There remains limited quantitative understanding of how non-production elements of food security will be affected, and of the adaptation possibilities in these domains. Nutritional quality of food and fodder, including protein and micronutrients, is negatively affected by elevated CO_2, but these effects may be counteracted by effects of other aspects of climate change (medium confidence).*

On average, agronomic adaptation improves yields by the equivalent of ~15-18% of current yields but the effectiveness of adaptation is highly variable (medium confidence) ranging from potential dis-benefits to negligible to very substantial (medium confidence). *Projected benefits of adaptation are greater for crops in temperate, rather than tropical, regions (medium confidence). Some adaptation options are more effective than others (medium confidence).*

Global temperature increases of ~4°C or more above late-20th-century levels, combined with increasing food demand, would pose large risks to food security globally and regionally (high confidence). *Risks to food security are generally greater in low latitude areas. Changes in temperature and precipitation, without considering effects of CO_2, will contribute to increased global food prices by 2050, with estimated increases ranging from 3 to 84% (medium confidence). Projections that include the effects of CO_2 changes, but ignore O_3 and pest and disease impacts, indicate that global price increases are about as likely as not, with a range of projected impacts from –30% to +45% by 2050.*

Adaptation in fisheries, aquaculture, and livestock production will potentially be strengthened by adoption of multi-level adaptive strategies to minimize negative impacts. *Key adaptations for fisheries and aquaculture include policy and management to maintain ecosystems in a state that is resilient to change, enabling occupational flexibility, and development of early warning systems for extreme events (medium confidence). Adaptations for livestock systems centre on adjusting management to the available resources, using breeds better adapted to the prevailing climate and removing barriers to adaptation such as improving credit access (medium confidence).*

A range of potential adaptation options exist across all food system activities, not just in food production, but benefits from potential innovations in food processing, packaging, transport, storage, and trade are insufficiently researched. *More observational evidence is needed on the effectiveness of adaptations at all levels of the food system"*

And importantly also, *"without adaptation, local temperature increases in excess of about 1°C above pre-industrial is projected to have negative effects on yields for the major crops (wheat, rice and maize) in both tropical and temperate regions, although individual locations may benefit (medium confidence)."*[45]

There are growing uncertainties in agriculture stemming from climate change, including variations in the availability and quality of land and water. Rural households are faced with increasing risks from natural shocks (drought, temperature and rainfall variability, for example) as well as longer-run changes over time such as groundwater depletion, soil degradation,

[45] IPPC, 2014. Reference as above.

unexpected changes in growing seasons, and declining access to other natural resources. Due to its effect on household income and consumption, climate change also has a magnified impact on the earnings of small-scale and subsistence agriculture. Gender implications of these trends are significant.

For instance, shifts in resource availability will require vulnerable communities in coastal areas, small island low-income countries and other low-income tropical countries to adapt their consumption patterns to new aquatic species that replace those commercial species moving to deeper cooler waters off continental shelves and into the northern latitudes. Ocean acidification has implications for availability of traditional fish and shellfish stocks and for marine aquaculture sites. Increased severe weather episodes are placing fishing communities and small scale fishers at particular risk, due to the danger of ocean fishing in face of severe weather episodes and artisanal vessels inadequate to protect fishers who must follow the stocks as they move further offshore. Small island low and middle income countries, in face of rising sea level, are facing the reality of shrinking coastlines and thus their Exclusive Economic Zones, further depleting their available resources. Aquaculture producers are facing higher incidence of disease due to climate change, as well as risk of escaped stocks from ponds during severe weather episodes.

Also remote communities, which are particularly sensitive to climate shocks, will increasingly rely on natural resources, particularly forests, to ensure their food security.

Possibilities for agronomic and breeding adaptations of food production to global warming are possible up to high levels of climate change. However, food security studies are urgently required to estimate the actual range of adaptations open to farmers and other actors in the food system and the implementation paths for these, especially when possible changes in climate variability are included.

The IPCC in its 5th assessment (2013) also underscores that climate change hazards increase or heighten existing gender inequalities, thereby contributing to the greater climate change vulnerability of many women. The nexus of gender, climate change, and agriculture is particularly complex. Adaptation and mitigation interventions in these three domains are not always well aligned because of a failure to recognize and manage the trade-offs that may result in policy contradictions. Women farmers often lose control over the resources, products, and market niches they traditionally manage once they become lucrative; men will often take over production and marketing, even of women's traditional crops. What appears as progress from one perspective may, when considered from another perspective, actually reveal negative side effects, such as women's increasing dependence and diminishing income opportunities, power, and traditional status.[46]

In summary, climate change already affects agriculture and food security, and, without urgent action, will put millions of people at risk of hunger and poverty.[47]

[46] World Bank, FAO and IFAD 2015. Gender in Climate-Smart Agriculture. Module 18 of the Gender in Agriculture Sourcebook. World Bank, Washington DC.

[47] FAO, 2016. The state of food and agriculture. Climate change, agriculture and food security.

6 Agricultural productivity and innovation

In the coming decades, the growing global demand for food, feed and biofuel will have to be met by significant increases in production of all major crops, livestock and fisheries. In 2012, FAO has projected that meeting the increased demand would require a 60 percent growth in agricultural output by 2050 over 2006 (AT2050). This figure was based on global population projections to 2050 of 9.11 billion people[48]. However, according to the most recent UN projections the world population is expected to grow at a faster rate, reaching 9.73 billion in 2050 (medium variant, 2015)[49]. This means more than 600 million additional people than previously expected, which would put additional pressure on food demand. Taking into account this higher population growth while keeping all other assumptions equal, global food demand is projected to increase by over 63% between 2005/06 and 2050[50]. As food production expanded by 15% between 2005/7 and 2012, the projected food demand increase from 2012 to 2050.would amount to approximately 49% (table 6.1).

Table 6.1 Agricultural output increase to match projected food demand, 2005-2050

	2005/07	2050	2005/07-2012	2012-2050
World				
Projected as in AT 2050	100.0	159.6	14.8	44.8
Projected with updated pop. (UN2015)	100.0	163.4	14.8	48.6
Sub Saharan Africa & South Asia				
Projected as in AT 2050	100.0	224.9	20.0	104.9
Projected with updated pop. (UN2015)	100.0	232.4	20.0	112.4
Rest of the world				
Projected as in AT 2050	100.0	144.9	13.8	31.2
Projected with updated pop. (UN2015)	100.0	147.9	13.8	34.2

Source: FAO Global Perspectives Studies (unpublished), based on UN DESA Population Division (2015) and AT2050.

Historically, even larger expansions of agricultural production could be observed in comparable time frames: Over the last half century (1961–2011), global agricultural production more than tripled, while the world's population expanded by 126 percent. Global cereal production grew by almost 200 percent, although the area harvested increased by only 8 percent (FAO, 2014). The livestock sector has been one of the fastest growing agricultural subsectors in low-income countries. Since the early 1960s, consumption of milk per capita has almost doubled, meat consumption more than tripled and egg consumption increased by a factor of five (SOFA, 2009)[51]. Although marine capture fisheries' contribution to human food and animal feed supply has levelled off over the last decade, aquaculture contribution continues to grow and in 2014,

[48] United Nations, Department of Economic and Social Affairs, Population Division. UN 2008 assessment, medium variant, as reported in AT2050

[49] United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: The 2015 Revision, Methodology of the United Nations Population Estimates and Projections. ESA/P/WP.242.

[50] GPS team's own calculations

[51] SOFA 2009 http://www.fao.org/docrep/012/i0680e/i0680e.pdf

the contribution of farmed fish to human consumption surpassed the quantity produced by capture fisheries.[52]

The most recent State of World Fisheries and Aquaculture (SOFIA) report published by the FAO (FAO 2016)[53] shows that over the past five decades per capita supplies of fish have doubled, despite a doubling of the human population over the same period. In the first half of this period, increases were due to increased capture fisheries landings while since the 1980s, virtually all the increases in supplies have come from aquaculture. Indeed, the report shows that in 2014 aquaculture's contribution to fish for human consumption exceeded that from capture fisheries.

The vast majority of aquaculture production comes from Asia – some 89%. By contrast, in Africa, where per capita protein intake is among the lowest of any region and where fish often supplies a high proportion of animal protein intake, aquaculture accounts for a little over 2% of global aquaculture production.

However, the world is facing new challenges through climate change and an increasingly constrained resource base, by e.g. degraded land and over-stressed water resources. For instance, a recent joint report by World Bank, FAO, IFPRI, and AES, estimates that by 2030, per capita fish consumption in Africa will have shrunk to 5.6 kg per annum, compared to a figure of 7.5 kg per annum in 2006 (World Bank 2013, table 3.7, p. 45)[54]. This is primarily attributed to lack of investment, gaps in technology and a lack of capacity, and increasing world market prices for fish. At the same time, new technological developments and innovations materialize. There is also greater involvement of the private sector and the use of intellectual protection instruments. Appropriate public policies, adequate public investments and innovative public-private partnerships will be needed to exploit the opportunities to maintain current productivity levels, sustainably raising them where possible, while reducing poverty and food insecurity.

6.1 Trends in yields, yield gaps and total factor productivity

Average yield growth of major staple crops – wheat, rice and maize – at the global level has been much slower in recent decades than the growth achieved in the 1960s and 1970s, ranging in the last decade slightly above 1% per year. (Figure 6.1). If substantial additional amounts of food must be produced in coming decades by means of yields increases, i.e. without major expansions of cultivated area, as projected in AT2050, cereal yields increases below 1% per year should be a worrying signal[55]

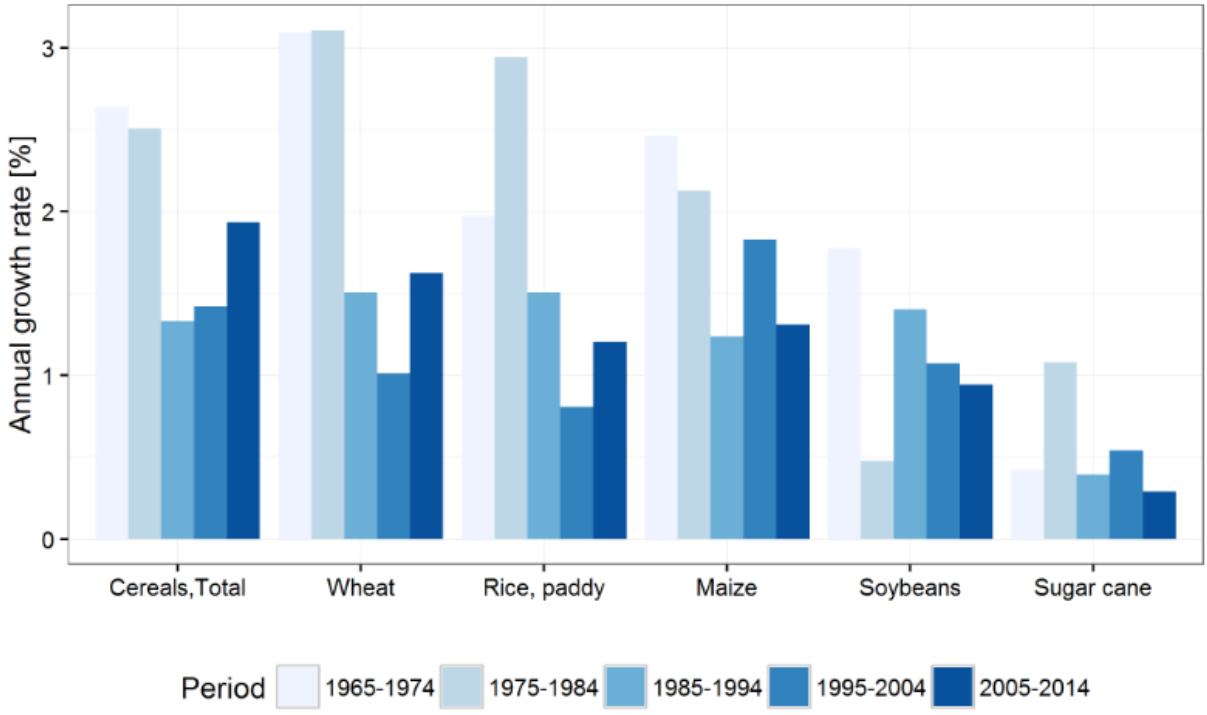
[52] State of World Fisheries and Aquaculture (SOFIA) 2016, FAO, Rome.

[53] FAO. 2016. The State of World Fisheries and Aquaculture. Rome. http://www.fao.org/3/a-i5555e.pdf

[54] World Bank, (2013). Fish to 2030 Prospects for Fisheries and Aquaculture, World Bank Report Number 83177-GLB

[55] According to AT 2050, cereal production would need to increase from 2.068 billion tons in 2005-07 to 3.009 in 2050 (Table 1.1), say a 43.4% increase. Assuming that 80% of this increase (as per in Table 4.4, referring to crop production) should come from yield increases, implies that yields should increase by around 35% by 2050, i.e.34 years. This translates in an annual growth of 0.9%

Figure 6.1 Average annual rate of change in crop yields (ton/ha), by decade and crop



Source: FAO Global Perspectives Studies. Calculations based on FAOSTAT production statistics (Download on 20 Sept 2016). Average annual growth rates in crop yields by decade, estimated using the OLS regression of the natural logarithm of crop yields on time and a constant term[56].

There are also very large differences in crop yields between high-income and low-income countries (Table 6.2). Yields of wheat and rice in low-income countries are currently about half those in high-income countries.

Table 6.2 Annual average crop yields (tonnes/ha) over the 2001 – 2012 period, by income grouping

	Wheat	Rice	Maize
Low-income countries	1.82	3.30	1.54
Lower-middle-income countries	2.74	3.65	2.74
Upper-middle-income countries	2.67	5.28	4.41
High-income countries	3.50	6.64	8.99
World	**2.92**	**4.16**	**4.87**

Notes: Country groupings are the same as those used by the World Bank (2012).

Source: FAO (2014).

[56] The commodity group "Cereals, Total" is taken from FAOSTAT and includes: wheat, rice (paddy), barley, maize, rye oats, millet, sorghum, buckwheat, quinoa, fonio, triticale, canary seed, Grains and mixed cereals not elsewhere specified.

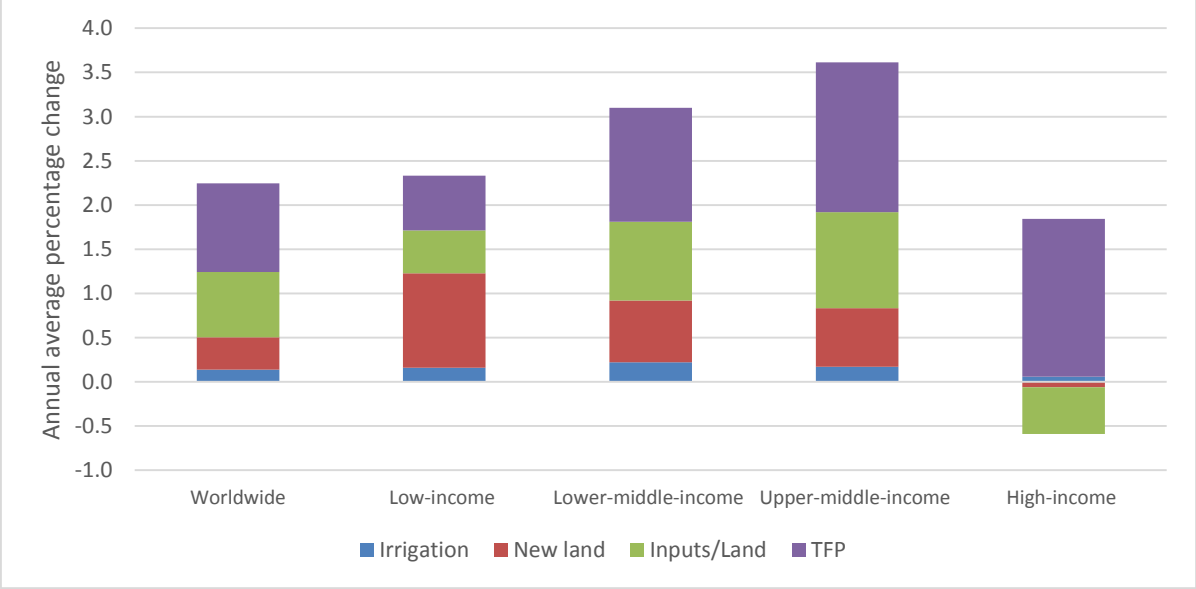
Yields for major crops (cereals, roots and tubers, pulses, sugar crops, oil crops and vegetables) also substantially vary by region. Estimated yield gaps – expressed as a percentage of potential yields – exceed 50 percent in most low-income countries and are largest in sub-Saharan Africa (76 percent) and lowest in East Asia (11 percent).

The gap between farmers' yields and technical potential yields reflects the largely suboptimal use of inputs and insufficient adoption of most productive technology, often linked to lack of market integration. Measures to reduce the gap offer high returns in terms of food security, nutrition and rural income gains. Studies show that high productivity gains can also be achieved by reducing gender gaps in small family farms (FAO, 2011b).

From the point of view of sustainable agricultural growth it is essential to use land, labour and inputs more efficiently as a result of technological progress, adoption of innovative and integrated practices and human capital development. Output growth achieved in this manner, and not expanded input use, is called total factor productivity growth (TFP), a comprehensive measure of productivity.

Globally, over the period 1961–2010, TFP growth accounted for about 40 percent of total growth in agricultural production, and has become increasingly dominant over time (Figure 6.2). In high- income countries, TFP growth has been the main contributor to agricultural output growth. In low-income countries, TFP growth has been modest, and most output growth has been achieved by expansion of agricultural areas. However, over the last decade TFP growth has increased significantly in low-income countries too. TFP grew at an average rate of around 2 percent per year since 2000 across major world regions.[57]

Figure 6.2 Sources of growth in agricultural output, by income group, 1961-2010



Source: Calculations by Fuglie, using[58] and updates of information presented in Fuglie (2012).

[57] Economic Research Service (United States Department of Agriculture). 2013. International agricultural productivity. Online dataset (available at http://www.ers.usda.gov/data-products/ international-agricultural-productivity.aspx).

[58] Fuglie, K.O. 2012. Productivity Growth and Technology Capital in the Global Agricultural Economy. In Fuglie, K.O., Wang, S.L. & Ball, V.E. Eds. Productivity Growth in Agriculture: An International Perspective. Oxfordshire, UK, CAB International.

The picture is more complex when looking at individual countries or sub-regions. Some large countries like Brazil, China, Indonesia, Russia and Ukraine have achieved much higher TFP growth rates than the corresponding regional average. Sub-Saharan Africa is lagging, but some countries like Cameroon, Congo, Kenya, Mali, Benin and Sierra Leone have achieved above average TFP growth rates in the 2000s (Yu and Nin-Pratt, 2011).

Productivity of aquaculture, in terms of tonnage production per area of pond /land use, has been increasing due to intensification of production methods. Little traditional pond aquaculture, once the mainstay of aquaculture in Asia, in which a range of carp species with complementary feeding behaviours was stocked in fertilised ponds, now remains. Today, most farmed fish and crustacean production is heavily, if not exclusively, reliant on feeds. Key drivers have been increasing land prices and the affordability of using feeds due to the high prices of farmed fish (Beveridge et al. 2013)[59].

6.2 Determinants of yield and productivity: the role of science and technology

Over the past decades increased use of land and inputs such as fertilizer, have played a major role in output growth. While growth through irrigation and fertilizer is no longer important in industrialized countries, and in major regions like Asia, fertilizer use in Sub-Saharan Africa remains very low and explains a large part of the lagging productivity.

Despite successes in increasing yields in the past, "*…it is now recognized that those enormous gains in agricultural production and productivity were often accompanied by negative effects on agriculture's natural resource base, so serious that they jeopardize its productive potential in the future. "Negative externalities" of intensification include land degradation, salinization of irrigated areas, over-extraction of groundwater, the buildup of pest resistance and the erosion of biodiversity. Agriculture has also damaged the wider environment through, for example, deforestation, and the emission of greenhouse gases and nitrate pollution of water bodies…*" (FAO, 2011, p. 5)[60].

However, the key to sustainable agricultural growth lies in growth in TFP. In countries with a large proportion of small family farms, promoting innovation among these farms holds the key to ensuring TFP growth. Similar arguments apply to aquaculture.

Over the long-run, productivity growth for the sector as a whole requires continuous technological progress, as well as social innovations and new business models. For agriculture and aquaculture to respond to future challenges, innovation will not only need to improve the efficiency with which inputs are turned into outputs, but also conserve scarce natural resources and reduce waste (OECD, 2011; Troell et al., 2014)[61].

[59] Beveridge, M C M, Thilsted, S H, Phillips, M J, Metian, M, Troell, M & Hall, S J. 2013. Meeting the food and nutrition needs of the poor: the role of fish and the opportunities and challenges emerging from the rise of aquaculture. *Journal of Fish Biology* **83**, 1067-1084.

[60] FAO 2011. Save and Grow: A policymaker's guide to the sustainable intensification of smallholder crop production. FAO UN Rome. http://www.fao.org/ag/save-and-grow/en/index.html

[61] Troell, M, Naylor, R, Metian, M, Beveridge, M, Tyedmers, P, Folke, C, Österblom, H, de Zeeuw, A, Scheffer, M, Nyborg, K, Barrett, S, Crépin, A-S, Ehrlich, P, Lewin, S, Xepapadeas, T, Polasky, S, Arrow, K, Gren, Å, Kautsky, N, Mäler, K-G, Taylor, S & Walker, B. 2014. Does aquaculture add resilience to the global food system? *Proceedings of the National Academy of Sciences* **111**, 13,257-13,263.

"*Currently, crops are grown under a wide range of production systems. At one end of the continuum is an interventionist approach, in which most aspects of production are controlled by technological interventions such as soil tilling, protective or curative pest and weed control with agrochemicals, and the application of mineral fertilizers for plant nutrition. At the other end are production systems that take a predominantly ecosystem approach and are both productive and more sustainable. These agro-ecological systems are generally characterized by minimal disturbance of the natural environment, plant nutrition from organic and non-organic sources, and the use of both natural and managed biodiversity to produce food, raw materials and other ecosystem service*" (FAO, 2011, p.17).

The farming practices required by the ecosystem approach will differ according to local conditions and needs. However, in the majority of cases they comprise:

- *Minimize soil disturbance by minimizing mechanical tillage* in order to maintain soil organic matter, soil structure and overall soil health;
- *Enhance and maintain a protective organic cover* on the soil surface, using crops, cover crops or crop residues, in order to protect the soil surface, conserve water and nutrients, promote soil biological activity and contribute to integrated weed and pest management;
- *Cultivate a wider range of plant species* – both annuals and perennials – in associations, sequences and rotations that can include trees, shrubs, pastures and crops, in order to enhance crop nutrition and improve system resilience.

Those three key practices are generally associated with conservation agriculture (CA), which is now adopted on about 117 million ha worldwide, or about 8 percent of total crop land. Highest adoption levels (above 50 percent of crop land) are found in Australia, Canada and the southern cone of South America. Adoption has been low in Africa, Central Asia and China but it is increasing (FAO, 2011), nonetheless high levels of dis-adoption are also observed. This underlines the need for a nuanced approach that takes the effects of climate change into account as well as the barriers to its adoption (Arslan et al. 2014; Grabowski et al. 2016; IAPRI 2016)[62].

The implementation of conservation agriculture, as well as other sustainable field level practices, such as agroforestry, integrated pest management, integrated crop-livestock-energy systems etc, requires technological innovation and investment in R&D, specifically for identifying technologies that allow conserving the resource base while maintaining and/or increasing yields and adapting them to the diverse situations. Investment is also needed to implement and support new organizational forms of R&D closer to farmers' realities, also on the basis of experiences of Farmers' Field Schools[63]. Last but not least, the institutional enabling

[62] Arslan, A., McCarthy, N., Lipper, L., Asfaw, S. and Cattaneo, A. 2014. "Adoption and intensity of adoption of conservation farming practices in Zambia," *Agriculture, Ecosystems & Environment*, Vol. 187, pp. 72–86.

Philip P. Grabowski, John M. Kerr, Steven Haggblade, Stephen Kabwe, Determinants of adoption and disadoption of minimum tillage by cotton farmers in eastern Zambia, Agriculture, Ecosystems & Environment, Volume 231, 1 September 2016, Pages 54-67, ISSN 0167-8809

IAPRI 2016. Qualitative Assessment of the Key Drivers to Adoption, Dis-adoption and Non-Adoption of Conservation Agriculture among Smallholder Farmers in Zambia. Report submitted to the European Union Delegation for Zambia and COMESA

April 2016, Indaba Agricultural Policy Research Institute, Lusaka, Zambia

[63] FAO 2016. *Innovative markets for sustainable agriculture: How innovations in market institutions encourage sustainable agriculture in developing countries.* Loconto, A., Poisot, AS., Santacoloma, P. (eds). Felt, U., Wynne, B., Callon, M., Gonçalves, M., Jasanoff, S., Jepsen, M., Joly, P.-B.t., Konopasek, Z., May, S., Neubauer, C., Rip, A., Siune, K., Stirling, A., & Tallacchini, M. 2007. *Taking European knowledge society seriously. Report of the expert group on science and governance to the science, economy and society directorate, Directorate-General for Research, European Commission.*

environment is crucial to ensure effective implementation to sustain the promotion and adoption levels.

6.3 Trends in science and technology and drivers

Following a decade of slowing growth in the 1990s, global agricultural R&D spending increased by an average 3.1 percent annual during the 2000–2008 period, rising from $24.98 to $33.59 billion in 2005 PPP prices.

Spending by China and India accounted for close to half of the global increase during 2000–2008. Other middle-income countries (particularly Argentina, Brazil, Iran, Nigeria, and Russia) also significantly increased their spending on public agricultural R&D during this period, and collectively accounted for one-fifth of total global spending growth.

In low-income countries, R&D spending grew by 2.3 percent per year during 2000–2008 (Table 6.3), driven largely by increases in the larger East African countries—Ethiopia, Kenya, Tanzania, and Uganda—after a decade of stagnation in the 1990s and early 2000s.

Table 6.3 Inflation-adjusted public agricultural R&D spending growth rates by decade, region and income group

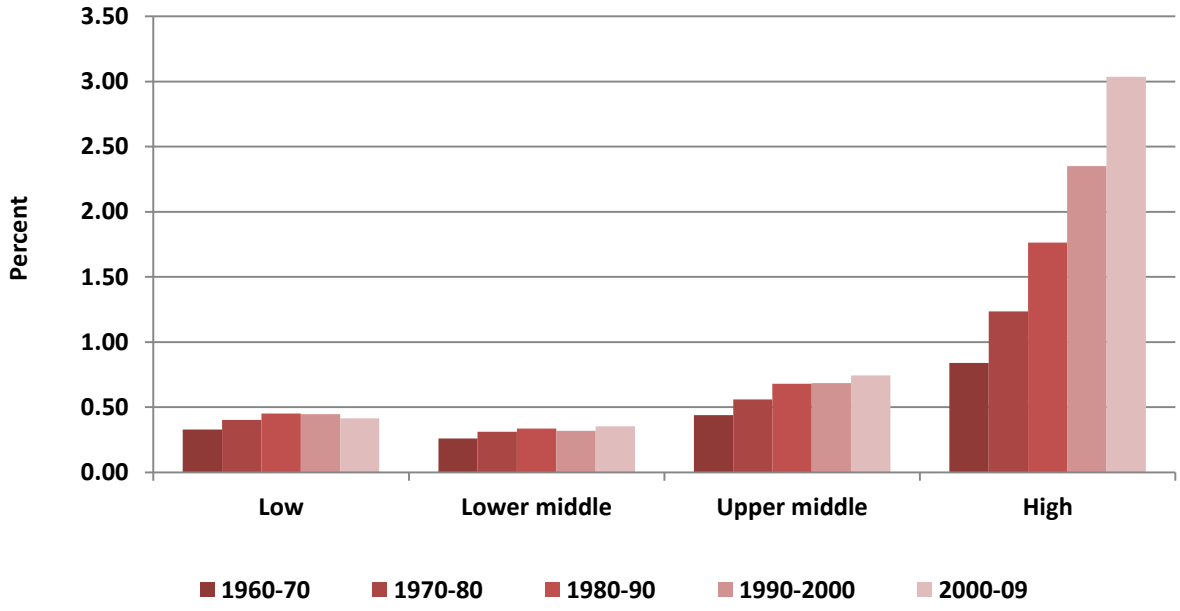
	1960-70	1970-80	1980-90	1990-2000	2000-09
Global	7.6	4.1	2.4	1.9	3.1
By income group					
Low-income	6.0	4.1	3.1	1.0	2.3
Lower-middle-income	6.7	3.3	3.1	3.2	4.6
lower-middle-income (excl. India)	5.4	4.1	2.0	0.8	4.1
Upper-middle-income	4.3	6.6	2.8	2.1	6.2
Upper-middle-income (excl. China)	6.1	6.2	1.9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

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

A commonly used indicator to assess countries' agricultural research efforts is the agricultural research intensity (ARI), which expresses national expenditure on public agricultural R&D as a share of agricultural GDP. There is no way to determine the "right" level of ARI, however, the United Nations Economic and Social Council's (ECOSOC's) resolution 2004/68, "Science and Technology for Development", recommends that governments increase their overall R&D expenditure for science and technology to at least 1 percent of national GDP. For the agriculture

sector, countries in both the low and the lower-middle-income groups are overall far from this target, although there are major differences within the groups (Figure 6.3).

Figure 6.3 Agricultural research intensity, averages by decade and income group



Note: Simple average of annual agricultural research intensity.

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

Private investment in R&D has risen strongly in recent decades, from 12.9 billion $ (PPP) in 1994 to 18.2 billion $ (PPP) in 2008.[64] Global private investment in R&D in agriculture and food processing accounted for about 21 percent of total R&D expenditures in 2008. Primary agriculture's share has fallen from 51 to 46 percent of the total. The vast majority of private research – perhaps 89–94 percent – takes place in high-income countries, but evidence from India (Pray and Nagarajan, 2012) and China (Pal, Rahija and Beintema, 2012) suggests that it has grown, and now accounts for 19 percent of total agricultural R&D spending in India and 16 percent in China (excluding food processing). No such figures have been collected for aquaculture.

Until recently, private agricultural R&D was concentrated in the mechanical and chemical sectors, but in recent decades there has been an increase in private investments in the life science sector, driven partly by changes to the governance of intellectual property rights for biological innovations (Wright and Pardey, 2006).The reduction in public extension services has also seen a growth in private sector dissemination of technologies and practices. In spite of the growing importance of private agricultural advisory services, for both economic and social reasons there is still a clear need for government to maintain a role in providing advice to farmers in many

[64] Beintema, N., Stads, G., Fuglie, K. & Heisey, P. 2012. ASTI global assessment of agricultural R&D spending: developing countries accelerate investment. Washington, DC and Rome, IFPRI, ASTI and GFAR.

countries[65]. Estimates of the rates of return to agricultural R&D suggest a very high social value of agricultural R&D. Annual internal rates of return of investments on agricultural R&D estimated in the literature range between 20 percent and 80 percent[66]. In low-income countries, the dollar-for-dollar impact of R&D investments on the value of agricultural production is generally within the range of 6 percent to 12 percent across countries[67,68,69] .

Creating closer linkages between R&D and extension, particularly using farmer-led research and other learning-based approaches, are effective means to expand adaptation and adoption of technology[70]. All this can contribute achieving the desired productivity improvements[71].

6.4 Innovations for improved agricultural productivity

Agricultural Biotechnology, defined as "*any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use*" (Article 2 of the Convention on Biological Diversity) can make significant contributions to sustainable intensification. These biotechnologies, of which genetically modified organisms (GMOs) is only one among them, encompass a broad range from low-tech approaches involving artificial insemination, fermentation techniques, biofertilizers etc. to high-tech approaches involving advanced DNA-based methodologies.

Whereas other agricultural biotechnologies have been little discussed outside of academic and research circles, a major and polarized debate about genetic modification and genetically modified organisms (GMOs) has been underway since the 1990s[72]. This debate revolves around the potential implications of GMOs for food security, the environment, biodiversity, human and animal health, control of the global food system and other issues. It is recognized that genetic modification can help in some circumstances to increase production and productivity, with possible implications for food security[73].

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[65] Compagnone C., Goulet F., Labarthe P. (Eds.), 2015. Conseil privé en agriculture. Acteurs, pratiques, marché. Dijon, Educagri Editions; Versailles, Quae.

[66] Alston, J. 2010. The Benefits from Agricultural Research and Development, Innovation, and Productivity Growth. OECD Food, Agriculture and Fisheries Working Papers, No. 31, OECD Publishing. dx.doi.org/10.1787/5km91nfsnkwg-en.

[67] Fan, S., Yu, B. & Saurkar, A. 2008. Public spending in developing countries: Trends, determination and impact. In: Fan, S. Ed. Public expenditures, growth and poverty. Baltimore, John Hopkins University Press

[68] Fan, S. & Zhang, X. 2008. Public expenditure, growth and poverty reduction in rural Uganda. African Development Review, 20(3): 466-496.

[69] FAO. 2012. State of Food and Agriculture: Investment in Agricultural for a Better Future. Rome.

[70] Darnhofer, I., Gibbon, D., & Dedieu, B. 2012. *Farming systems research into the 21st century: The new dynamic*: Springer Netherlands.

[71] Waters-Bayer, A., Kristjanson, P., Wettasinha, C., van Veldhuizen, L., Quiroga, G., Swaans, K., & Douthwaite, B. 2015. "Exploring the impact of farmer-led research supported by civil society organisations."*Agriculture & Food Security* 4(1): 1-7. Scoones, I., & Thompson, J. 2009. *Farmer first revisited : Innovation for agricultural research and development*. Rugby, UK: Practical Action Pub.; IPES-Food. 2016. From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems. International Panel of Experts on Sustainable Food systems.

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

[73] A comprehensive global meta-analysis, on 147 published biotech crop studies over the last 20 years worldwide, found that on average GMO technology adoption has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68% (Klümper & Qaim, 2014). In 2014, GMO crops were grown in 28

However, GMOs pose concerns about the potential risks regarding the effects on human and animal health and the environment and there is the need to carefully evaluate on a case-by-case basis the potential benefits and risks associated with the application of modern technologies to increase plant and animal productivity and production. One unfortunate consequence of this long-running debate is that the other biotechnologies have been overshadowed, with the result that too little focus has been given to their potential merits and the role that they can play for food security and sustainable development. For example, New Rice for Africa (NERICA) varieties were developed using biotechnologies that enable two species of cultivated rice, African rice and Asian rice, to be crossed. These NERICA varieties combine the high yields from the Asian rice with the ability of the African rice to thrive in harsh environments and are now widely distributed in sub-Saharan Africa [74].

Biotech crops are the fastest adopted crop technology in recent years (James, 2014). However, investment patterns in biotechnology R&D are highly uneven in low-income countries. Brazil and India each spend less than one tenth of the Chinese agricultural biotechnology budget, but vastly out-spend the whole of sub-Saharan Africa.

Most new biotechnologies have originated outside low-income countries, so improved North-South links to facilitate capacity building and technology flow are especially crucial. The lack of adequate and sustained investments remains a major limiting factor in most low-income countries. . Moreover, many products, such as new crop varieties, are part of private sector bodies with no explicit public good missions. A major challenge is to find ways to facilitate the uptake of agricultural R&D discoveries into low-income countries and non-commercial crop staples without compromising the innovative processes that often produce such discoveries. This has led to the establishment of a range of public-private partnerships with the broad objective of making the products of existing biotechnologies available to smallholders in low-income countries, normally in areas where the private sector has little commercial interest.

Also nanotechnology is seen as offering opportunities for innovative products in agriculture and along the chain that may help address the current challenges of sustainability, food security and climate change. Nanotechnology-based food and health food products, and food packaging materials, are available to consumers in some countries already and additional products and applications are currently in the research and development stage, and some may reach the market soon. In view of such progress, it is expected that nanotechnology-derived food products will be increasingly available to consumers worldwide in the coming years (FAO/WHO, 2010).

However, despite the numerous potential advantages of nanotechnology and the growing trends in publications and patents, agricultural applications have not yet made it to the market consumers. The main factors limiting the development of these applications are low investments in manpower training and in research infrastructure. (Parisi, Vigani & Rodríguez-Cerezo, 2015).

Citizen resistance to biotechnology and nanotechnology, as well as fears of commercial losses, have also played a significant role in limiting the use and spread of these technologies and these trends are found across the world[75]. Recent policy pushes towards responsible research and

countries on 181.5 million hectare, up from 1.7 million hectare in 1996. 18 million farmers grow GMO crops, including 14.8 million farmers in India and China.

[74] The above paragraph heavily borrows from the web site of the "International Symposium on the role of biotechnologies in Sustainable food systems and nutrition". FAO 15-17 February 2016 http://www.fao.org/about/meetings/agribiotechs-symposium/faqs/en/

[75] David, K.H., & Thompson, P.B. 2008. *What can nanotechnology learn from biotechnology? : Social and ethical lessons for nanoscience from the debate over agrifood biotechnology and gmos*. 1st ed. Amsterdam; Boston: Elsevier/Academic Press.

innovation may be able to improve the citizen-science dialogues around the introduction of new and emerging technologies[76].

Direct face-to-face extension services are increasingly being complemented and sometimes replaced by communications technology such as mobile phones, the Internet and more conventional mass media – radio, video and television. ICT can play an important role in informing farmers and rural entrepreneurs on such issues as weather conditions, input availability, dealers, financial services, market prices and buyers.

Mobile phones are of particular relevance and have great potential for improving digital and financial inclusiveness. Subscriber penetration stands at 59 percent in low-income countries, and is projected to grow rapidly (Figure 4.4). By 2020, more than 90 percent of the incremental 1 billion new mobile subscribers are forecast to come from low and middle income countries (GSMA, 2016).

Mobile phones help overcome isolation, in effect shortening the distance between previously isolated smallholders and the other actors involved in producing, processing, transporting, marketing, and regulating food[77] (Conway, 2016). They can also speed up the supply of inputs through e-vouchers and real-time tracking of inventory.

Extension services have evolved in past decades away from top-down training-and-visit approaches aiming at 'technology transfer", to participatory and discovery-based approaches, and facilitation of rural innovations. For example, the Farmer Field Schoolssupport farmers to build their technical and organizational skills and generate local innovations, adapting technologies to local needs and blending them with local knowledge. This has resulted in many cases in significant increases in yields and incomes, reduced chemical use, improved social capital and gender relations. FFS have spread to over 90 countries and trained an estimated 20 million farmers. Action-research approaches involving farmers, researchers and rural advisors and NGOs, and farmer-researcher networks have also enabled significant successes.

Climate-Smart Agriculture (CSA), aimed at sustainably increase food security and incomes, adapt and build resilience to climate change while capturing potential mitigation co-benefits in food and agricultural systems, connects selected innovations such as agro-ecology, conservation agriculture, development of drought- or saline-tolerant crop varieties, agroforestry (FAO, 2010)[78]. More than 30 countries, specifically in Sub-Saharan Africa, explicitly referred to CSA in their Intended Nationally Determined Contributions (INDC) to reduce GHGs emissions, after the twenty-first Conference of Parties (COP21).In the livestock sector, CSA has induced an orientation to mixed crop-livestock systems and sustainable livestock farming, in which the environment is integrated with the objective to prevent degradation. Pasture and forage crops in rotation enhance soil quality and reduce erosion; livestock manure, in turn, contributes to soil fertility. Livestock can buffer the negative impacts of low rainfall periods by

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Gruère, G., & Sengupta, D. 2009. "Gm-free private standards and their effects on biosafety decision-making in developing countries." *Food Policy* 34 (5): 399-406; Aerni, P., & Bernauer, T. 2006. "Stakeholder attitudes toward GMO's in the Philippines, Mexico, and South Africa: The issue of public trust." *World Development* 34 (3): 557-575; Fairfield-Sonn, J.W. 2016. "Political economy of GMO foods." *Journal of Management Policy and Practice* 17 (1): 60; Stilgoe, J., Owen, R., & Macnaghten, P. 2013. "Developing a framework for responsible innovation." *Research Policy* 42 (9): 1568-1580.

[76] Stilgoe, J., Owen, R., & Macnaghten, P. 2013. "Developing a framework for responsible innovation." *Research Policy* 42 (9): 1568-1580.

[77] Conway, G. 2016. Recipe for a New Revolution. Africa's Twenty-First Century Agricultural Transformation. Foreign Affairs, Special Issue.

[78] FAO, 2013. *Climate Smart Agriculture Sourcebook.* Food and Agriculture Organization of the United Nations, Rome, Italy. Many Sustainable Development Goals can be supported through the CSA

consuming crop residue that in "plant only" systems would have been considered crop failures. In addition, marginalized land is used efficiently by livestock in various pastoral systems.

The abovementioned trends are changing the conduct and dissemination of technologies. They present positive opportunities for raising productivity and meeting new challenges, but there is also the risk of rising disparities between high-income and emerging countries and those lagging behind. The levels of public and private investment in R&D vary markedly by country and are concentrated in high-income and a few emerging countries. The rising importance of biotechnology means that less advanced, low-income countries face even higher costs associate with R&D. Ownership of technologies by private companies or high-income and emerging countries restricts the diffusion of new technologies in countries that are already least able to afford them, but where the benefits may be substantial. The greater involvement of the private sector and the use of proprietary technologies in the face of continued widespread poverty and climate change reinforces the importance of regulation and the strengthening of public good providers such as the CGIAR and regional and national systems. Public intervention is also required for R&D in Conservation Agriculture/Climate-Smart Agriculture, which are assumed to reduce the negative impact on the environment, prevent further climate change and reduce the probability of natural hazards. As the impacts of findings in these domains are likely to be diffused across users and spanning on period, they may not attract limited private investment.

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7 Conflicts, crises and natural disasters

7.1 Impacts on food security – conflicts and protracted crises

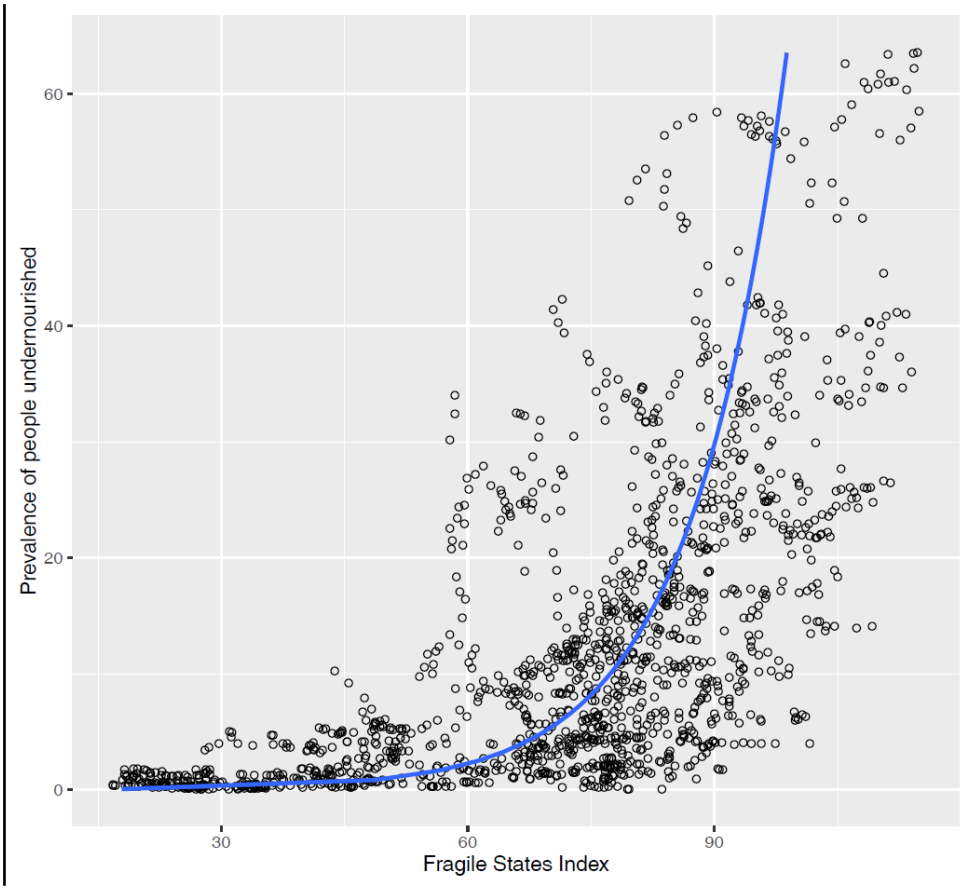
While acute and chronic hunger remain a global problem, and severe hunger can exist even without conflict, conflict has strong and unambiguous adverse effects on hunger, nutrition and overall sustainable development. Conflict is the major driver of food insecurity and chronic and acute malnutrition; each famine in the modern era has been characterized by conflict. Conflicts generate uncertainty about satisfying future needs by reducing food availability, disrupting access to foodstuffs, food preparation facilities or healthcare resources, and undermining non-formal as well as established social protection systems[79].

Most conflicts strike hardest in rural areas, heavily impacting agricultural production and rural livelihoods. This is particularly true for civil conflicts, which in recent years have become the most common form of armed conflict[80]. Poverty rates are 20 percentage points higher in countries affected by repeated cycles of violence over the last three decades. Every year of violence in a country is associated with lagging poverty reduction of nearly one percentage point[81].

Conflict causes vulnerable men, women, girls and boys and at risk communities to lose access to the range of resources necessary for food and agriculture production. This is neither accidental nor incidental; access to resources is lost through forcible or corrupt seizure of natural resources and displacement from land, homes, fishing grounds and livestock grazing areas, among other factors. Denials of access, as well as the destruction of food stocks, have been increasingly used as deliberate tactics of war. This is in direct violation of international humanitarian law and human rights laws, which specifically prohibit the targeting of food production systems, including irrigation infrastructure, standing and stored crops, livestock and other sources of livelihood and food security.

[79] Simmons, E. 2013. *Harvesting Peace: Food Security, Conflict, and Cooperation*. Environmental Change and Security Program Report Vol. 14, Issue 3. Woodrow Wilson International Center for Scholars: Washington DC.
[80] Center for Systemic Peace. 2012. http://www.systemicpeace.org/. Civil conflicts are those between a state and an opposition group that aims to take power over the central government, or in a region, or to change government policies.
[81] World Bank. 2011. *World Development Report 2011: Conflict, Security, and Development*. Washington, DC: The World Bank.

Figure 7.1 Burden of hunger and degree of *fragility (all countries, 2006-2014)*

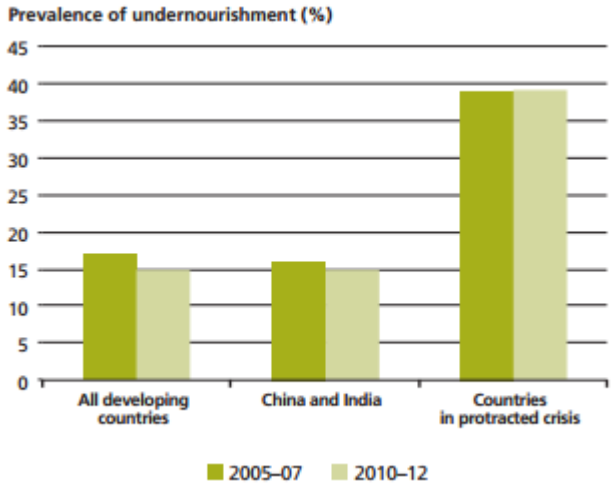


Source: FAO (for Prevalence of Undernourishment data) and Fund for Peace (for fragile states index)[82].

Countries with the highest levels of undernourishment tend to be those engaged in, or recently emerged from, violent conflict. High risk of conflicts is a key characteristic of fragile states and the probability of a high burden of hunger rises exponentially with the degree of fragility (Figure 7.1). The Central African Republic and Chad are among the worst-scoring countries and both experienced violent conflict and political instability in recent years. In contrast, Angola, Ethiopia and Rwanda, hunger levels have fallen substantially since the end of the large scale civil wars of the 1990s and 2000s.

[82] Source: FAO (for Prevalence of Undernourishment data) and Fund for Peace (for fragile states index). The fragile states index is based on twelve indicators of state vulnerability: social (4), economic (2), and political (6). The higher the index the greater the risk of violence and conflict. The threshold between situations of "stability" and "fragility" is 70, right at the point in the graph where the probability of high prevalence of undernourishment rises exponentially. Each point in the graph refers to country estimates for each year during 2006-2014.

Figure 7.2: Prevalence of undernourishment and protracted crises



Source: FAO, 2015. The state of Food Insecurity in the world p.37

Protracted crises are situations where a significant proportion of the population is acutely vulnerable to death, disease and disruption of livelihoods over a prolonged period of time, and which are frequently characterised by violent conflict[83]. FAO data show that, on average, the proportion of people who are undernourished is between two and a half and three times as high in countries with a protracted crisis as in other low-income countries (Figure 7.2). Not all countries with a protracted crisis present very high levels of undernourishment as in some of these countries crises are localized to certain areas or regions. In 2013, there were approximately 172 million undernourished people in countries in protracted crisis – roughly 20 percent of the world's undernourished people.

Of the 21 countries with protracted crisis identified in 2013 only Ethiopia reached the MDG 1c target of halving the proportion of undernourished population. All other countries reported either insufficient progress, or even deterioration. Ethiopia's achievement was largely thanks to sustained political commitment and efforts targeting intervention to improve food production and nutrition[84].

Recent conflicts like the ongoing civil war in Syria, a Middle Income Country, are major shocks that have led to massive displacement of people and widespread hunger and malnutrition. In Syria, 8.7 million people are food insecure – representing nearly two-thirds of the 13.5 million people in need of humanitarian assistance. Half the Syrian population once worked in agriculture, but now livestock herds have been reduced by half and wheat production is down by 40 percent, compared to the pre-conflict average [85]. Similarly, in South Sudan, the livestock sector, a key livelihood source for the majority of the population, lost an estimated USD 2 billion in potential GDP since the current conflict started in December 2013 and end 2015[86].

Mortality caused by conflict through food insecurity and famine can by far exceed deaths caused directly by violence. Between 2004 and 2009 approximately 55,000 people a year lost

[83] See also the Committee on World Food Security's *Framework for Action for Food Security and Nutrition in Protracted Crises*, endorsed in October 2015 (http://www.fao.org/3/a-bc852e.pdf).
[84] FAO, IFAD and WFP. 2015. *The State of Food Insecurity in the World: Meeting the 2015 international hunger targets: taking stock of uneven progress*. FAO: Rome.
[85] http://www.fao.org/emergencies/fao-in-action/stories/stories-detail/en/c/382638/
[86] FAO. 2016. *The Impact of Conflict on the Livestock Sector in South Sudan*. Final draft, unpublished.

their lives as a direct result of conflict or terrorism[87]. In contrast, as a result of famine caused by drought and conflict, more than 250,000 died in Somalia alone between 2010 and 2012[88].

The causal effects may differ across conflict zones, but commonly observed features are that conflicts disrupt food production through physical destruction and plundering of crops and livestock, harvests and food reserves; they prevent and discourage farming; they disrupt food transportation systems; they destroy farm assets and capital; they conscript or entice young men – and sometimes young women – to fight, taking them away from work at the farm; they cause the survivors of conflict to suffer from psycho-social traumas and disabilities; and they suppress income earning livelihoods and occupations. There has been a reported rise of conflict-related sexual violence: rape is used as a weapon of war, and as a result, the survivors suffer from sexually transmitted diseases, stigmatization, and trauma, affecting their health as well as productive capacities[89]. Conflict also makes it difficult for governments and humanitarian actors to reach those in need to address food security and nutrition and support agricultural livelihoods.

Conflict directly and indirectly also affects agricultural development in the medium- and longer-terms. Agricultural losses for all low-income countries due to conflict between 1970 and 1997 averaged USD 4.3 billion annually, far exceeding the value of development assistance to those countries[90]. Similarly, the presence or risk of conflict discourages private investment in agriculture, even long after conflicts have ceased.

The consequences of conflict, including the extreme measures necessary for survival, manifest specifically and often differently according to the age and gender of those affected. The relative relations of power and marginalization in society tend to be amplified as a result of the stressors (as well as the opportunities for exploitation) of conflict contexts. The gender inequalities women and girls face limit their access to productive resources, services, and decision-making. Thus their relative lack of equality, their burdens as caregivers for the young, aged and infirmed, and their central role in food production and other responsibilities expose them to particularly vulnerable situations. Recruitment into fighting forces drains key sources of labour, especially men and boys, from agriculture production, a problem exacerbated over the long term due to war-related disabilities, with the consequent increase in the role of women and the elderly in carrying forward the agriculture sector. Women take up new economic roles during conflict situations, while their domestic burdens increase: they care for the sick and the disabled, and carry out the backbreaking work of water and fuelwood collection in the rural settings, often exacerbated by compounding natural hazards, such as drought[91].

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[87] The Geneva Declaration on Armed Violence and Development. 2011. *Global Burden of Armed Violence 2011: lethal encounters*. GDAVD: Geneva. (http://www.genevadeclaration.org/measurability/global-burden-of-armed-violence/global-burden-of-armed-violence-2011.html).

[88] http://www.fao.org/somalia/news/detail-events/en/c/247642/.

[89] United Nations Security Council: Report of the Secretary General on Conflict-related Sexual Violence 2015 S/2015/203 http://www.securitycouncilreport.org/atf/cf/%7B65BFCF9B-6D27-4E9C-8CD3-CF6E4FF96FF9%7D/s_2015_203.pdf In addition to the Secretary-General's report, see the example of Sudan (Human Rights Watch 2016) https://www.hrw.org/news/2016/01/27/sudan-rape-weapon-war

[90] SOFI 2002.

[91] UN Women (2012): Women working for recovery: The impact of female employment on family and community welfare after conflict. By Patricia Justino.
http://www.unwomen.org/~/media/Headquarters/Media/Publications/en/05BWomenWorkingforRecovery.pdf
Care (2016): Women, work & war. Syrian women and the struggle to survive five years of conflict. Research study. By Beatrix Buecher and James Rwampigig Aniyamuzaala.
http://www.care-international.org/files/files/CARE_Women_Work_War_report.pdf
Thulstrup, A. & Henry, W.J. (2014): Women's access to wood energy during conflict and displacement: lessons from Yei County, South Sudan. Unasylva 243/244, Vol. 66, 2015/1–2.
https://cleancookstoves.org/binary-data/RESOURCE/file/000/000/348-1.pdf

The lasting effect of conflicts is also manifested through its impact on nutrition, especially undernutrition during early childhood, with many of those affected suffering from lifelong physical and/or mental handicaps.

On a more positive note, an 'unheralded achievement' of the past 50 years, has been the end of the age of 'calamitous famines' - those that kill more than one million people - and a significant reduction in 'great famines' - those that kill 100,000 people or more[92]. It is posited that this may be due to the interrelated effects of factors such as the end of the Cold War, the adoption of international human rights norms and the rise of globalisation. This is not to infer that famines are over - but that today's famines are mostly caused by violent conflict, exacerbated by natural disasters, and more often are local[93].

Conflicts are on the rise again. The end of the Cold War, marked by the collapse of the Soviet Union in 1991, had a dramatic effect on the general level of armed conflict in the global system. The levels of both interstate and societal warfare declined dramatically through the 1990s and this trend continued into the early 2000s, falling over 60 percent from peak levels. While a growing global population might be expected to provoke an increasing number of violent conflicts, this was effectively inverted between 1995 and 2003. However, the prevalence of conflicts globally - particularly civil conflicts - has increased markedly since the early-mid 2000s, due to the rapid emergence of several factors at both international and national levels[94].

The root causes of conflict are complex, nonlinear, and mediated by a host of factors. Over one-third of countries classified in 2015 as fragile had experienced recent conflicts, reflecting dynamic interrelationships among poverty (including hunger), governance and conflict[95]. Recent conflicts have destabilized entire regions, exponentially increased the number of forcibly displaced, drained global humanitarian resources and brought untold misery to families and communities.

In 2014, there were 424 political conflicts and 46 extremely violent conflicts globally[96]. Since 2008, the number of active civil wars has almost tripled, from four to eleven[97]. However, it is important to note that such trends are geographically variable. For example, armed conflict events in Africa overall decreased by 14 percent between 2014 and 2015, but the overall trend was not homogeneous; whilst there was a continent-wide decrease, in the same period, fifteen African states saw an increase, clustered in specific regions[98].

2016 Global Peace Index (GPI) Report[99] concludes that the world became less peaceful in 2015, reinforcing the underlying trend of declining peace over the last decade. The report also describes growing "global inequality in peace", with the most peaceful countries continuing to improve while the least peaceful are falling into greater violence and conflict. The Syrian civil

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[92] De Waal, A. 2015. *Armed Conflict and the Challenge of Hunger: Is an End in Sight?* in *2015 Global Hunger Index: Armed Conflict and the Challenge of Hunger*. Bonn, Washington, DC, and Dublin: Welthungerhilfe, International Food Policy Research Institute, and Concern Worldwide.

[93] Keen, D. 2008. *Complex Emergencies*. London: Polity.

[94] Cilliers, J. 2015. *Future (im)perfect? Mapping conflict, violence and extremism in Africa*. Institute for Security Studies.

[95] OECD/DAC. 2015. *States of Fragility: Meeting post-2015 ambitions*. Page 33. Available from: http://www.oecd-ilibrary.org/docserver/download/4315011e.pdf?expires=1466644536&id=id&accname=guest&checksum=2A65909481242A852961A70B50605238

[96] OCHA. 2016. *World Humanitarian Data and Trends 2015*.

[97] Report of the Secretary-General on the United Nations and conflict prevention: a collective recommitment (S/2015/730).

[98] See the Armed Conflict Location & Event Data Project (ACLED) http://www.crisis.acleddata.com/african-overview-2015/.

[99] Available at http://static.visionofhumanity.org/sites/default/files/GPI%202016%20Report_2.pdf.

war is now in its sixth year. Conflict and lawlessness persist in parts of the Central African Republic, Iraq, Libya, Nigeria, South Sudan, Ukraine, Yemen and elsewhere. Conflicts are becoming more complex and intractable, and their human and financial toll increasingly intolerable.

The drivers of conflicts range from ethnic tensions, religious differences, discrimination and marginalisation, poor governance, limited state capacity, population pressure and rapid urbanization, through to other factors such as poverty and youth unemployment. Some conflict drivers specifically relate to FAO's mandate and competencies. These include conflicts that have been driven by, *inter alia*, competition for land, water and other natural resources, the multiple dimensions of food insecurity, the neglect by governments of marginalized areas (such as arid and semi-arid landscapes essential for livestock-dependent populations, poor rural areas, or subsistence fishing grounds), or environmental mismanagement.

Using the measureable criteria employed for the 2010 State of Food Insecurity in the World, between 2008 and 2013 the number of countries with a protracted crisis situation has remained relatively static, fluctuating between 20 and 22. The majority of countries with protracted crisis are in Africa, with the percentage increasing slightly from 77 percent in 2008 to 81 percent in 2013.

Approximately 80 percent of humanitarian funding appeals are conflict related. In 1990, one-fifth of the global poor lived in fragile states, whereas now the most recent projections suggest that approximately half of the global poor now live in states characterized by fragility and conflict; and 93 percent of people living in extreme poverty are living in countries deemed as fragile or environmentally vulnerable, or both[100].

A concerning trend is that the implications of conflict-induced food insecurity are no longer limited to specific countries or regions, but have global impacts. In 2015, over 65 million people worldwide were forcibly displaced, the highest number since the end of World War II. The proximate effects of today's conflicts are increasingly echoed across the broader global landscape as conflict-affected people move across and within countries, regions and continents in a bid to manage the risks and consequences of conflict. There is a deepening awareness of how food insecurity in one part of the world can influence social services, political systems and national security elsewhere.

Cognizant that the Millennium Development Goals neither explicitly nor adequately addressed the worrying trend in conflicts worldwide, the 2030 Agenda for Sustainable Development calls for more collaborative approaches to conflict prevention, mitigation, resolution and recovery. The 2030 Agenda recognizes peace as a vital threshold condition for development as well as a development outcome in its own right, and that conflict inhibits sustainable development. One of the seventeen global Sustainable Development Goals (SDGs) aims to significantly reduce all forms of violence, and work with governments and communities to find lasting solutions to conflict and insecurity (SDG 16).

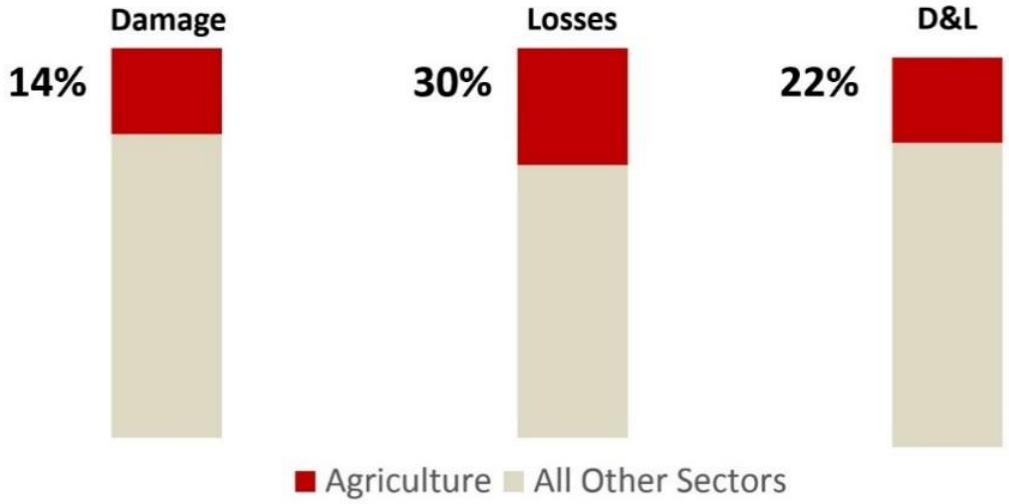
7.2 Impacts on food security – natural disasters

Natural disasters represent a threat to sustainable development and hinder progress towards hunger eradication, improved nutrition and food security. Geological, climate and weather related disasters continue to affect the lives and livelihoods of men and women worldwide. In particular, natural disasters trap vulnerable people in a cycle of poverty because of their lower levels of resilience and coping capacity. The differentiated impact of disasters on men and

[100] Global Humanitarian Assistance Report 2015.

women is primarily caused by the existing gender inequalities manifested. As a 2007 study conducted by London School of Economic shows, taken a sample of up to 141 countries over the period 1981 to 2002, natural disasters and their subsequent impact, on average, kill more women than men or kill women at an earlier age than men related to women's lower socio-economic status (Neumayer and Plümper, 2007).

Figure 7.3: Disasters' damages and losses affecting agriculture in low and middle - income countries (2003-2013)



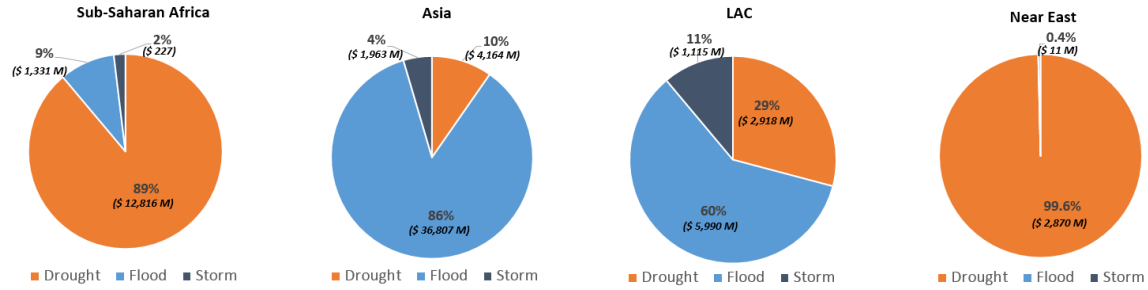
Source: FAO report on Impact of Disasters on Agriculture and Food Security

The FAO report on Impact of Disasters on Agriculture and Food Security[101] highlights that, between 2003 and 2013, 22 percent of the total economic damage (i.e. to physical assets and infrastructure) and losses (i.e. changes in economic flows) caused by natural disasters in low-income countries was absorbed by agriculture, with the share rising to 25 percent when only climate-related disasters are considered, and up to 84 percent in the case of drought. Production losses experienced by the agriculture sectors in the aftermath of a disaster were twice as high as the direct damage to agricultural assets and infrastructure (Figure 7.3).

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

[101] FAO. 2015. *The Impact of Natural Hazards and Disasters on Agriculture and Food Security and Nutrition: A call for action to build resilient livelihoods*. Available from: http://www.fao.org/3/a-i4434e.pdf.

Figure 7.4: Crop and livestock production losses after medium-to-large scale disasters in low and middle-income countries, by region (2003-2013)



Source…

At regional level, the impact of natural disasters reflects varying climate risks and vulnerabilities. Between 2003 and 2013, drought was the most harmful disaster for agriculture in Sub-Saharan Africa and the Near East; Asia was mainly affected by floods; and Latin America and Caribbean countries were affected mostly by floods, and to a lesser extent by drought and storms (Figure 7.4).

Food insecurity and natural disaster risk reinforce one another. Natural disasters have shattering consequences on food security, and food insecurity inversely increases the risk of exposure to disasters, leading to a downward spiral in which affected people lurch from one crisis to the next. Food insecure people may find themselves forced to take desperate measures to address immediate needs, often compromising their livelihoods, their health, and their dignity, and increasing their vulnerability and exposure to disasters. At the same time, the most vulnerable low-income countries are the ones particularly exposed to the risk of food insecurity and malnutrition resulting from natural disasters.

Natural disasters can cause unemployment and/or a decline in wages and therefore income among farmers and farm labourers. They lower the availability of food commodities in local markets, leading to food inflation. These pressures reduce households' purchasing capacity, restrict access to food, deplete savings and can force the sale of vital productive assets and erode livelihoods. Ultimately, the quantity and quality of food consumption are reduced and food insecurity and malnutrition increase, particularly among the most vulnerable households. For instance, the 2010 floods in Pakistan affected 4.5 million workers, two-thirds of whom were employed in agriculture, and over 70 percent of farmers lost more than half of their expected income.

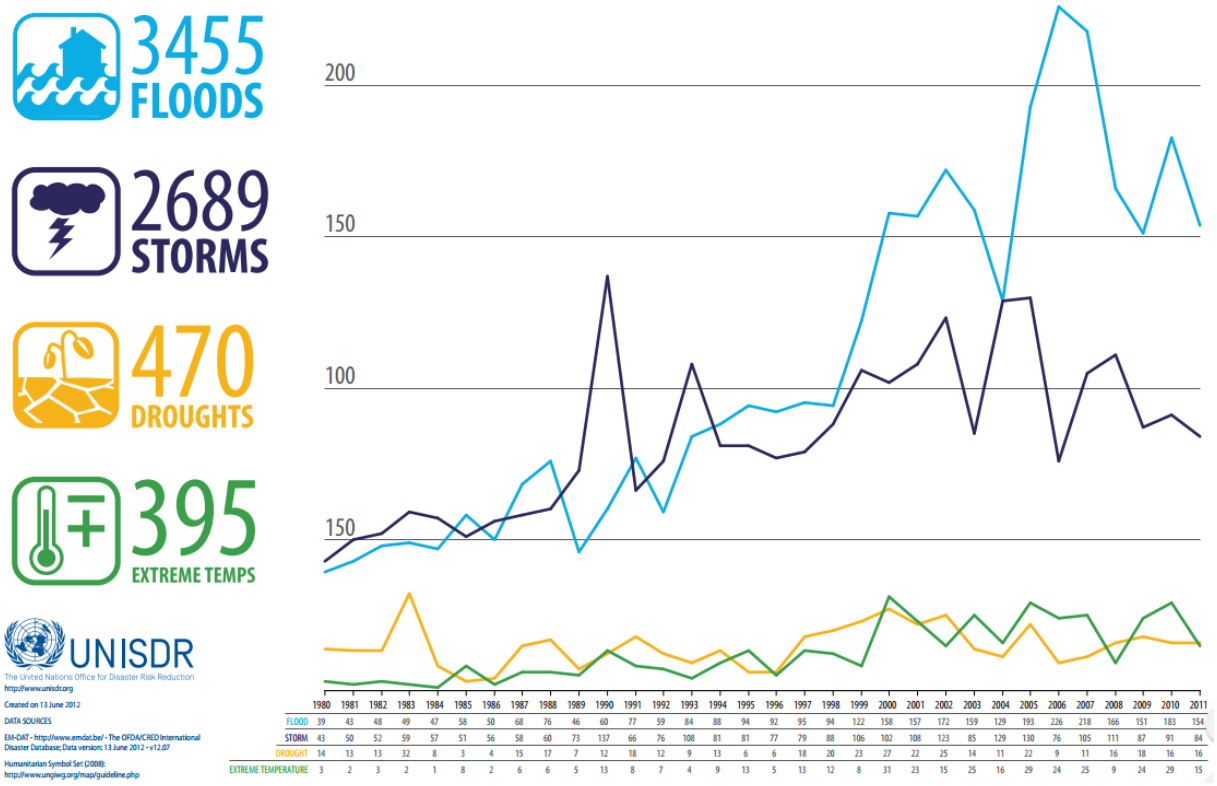
Over the last three decades, there has been a rising trend in the occurrence of natural disasters worldwide, with consequent economic damage (Figure 7.5). This is particularly noteworthy in relation to climatological events such as droughts, hydrological events like floods and meteorological events such as storms. The increase in weather-related events is of significant concern to the agriculture sector, given the sector's dependence on climate.

The intensity of these disasters is also increasing, and it may continue to increase as result of climate change. For some regions, climate change will result in more intense precipitation, leading to more floods, yet longer dry periods between rain events, leading to more drought. Droughts are expected to intensify, especially in the subtropics and low- and mid-latitudes.

The 2015/16 El Niño was one of the strongest observed over the last 50 years and its impacts were felt world-wide. Several severe tropical cyclones affected the Pacific Islands and Southeast Asian countries throughout the 2015/16 cyclone season. The year 2015 was the hottest on record, with the average global temperature much higher than in 2014, which itself was a record. Furthermore, 2016 is expected to set a new record, meaning that global

temperature records will have been broken for three years running. The 2016 heat-wave in South Asia is set to affect hundreds of thousands of people. Agricultural production may fall by as much as 2 percent each decade for the rest of the end of this century as a consequence of rising temperatures.

Figure 7.5 Number of climate-related disasters around the world (1980-2011)



Source: UNISDR 2016. http://www.preventionweb.net/files/20120613_ClimateDisaster1980-2011.pdf

Climate change-related extreme weather events are expected to exacerbate a deepening global need for humanitarian assistance, including by contributing to conflict risks and associated pressure on populations to move. Whilst climate change *per se* is not necessarily associated with violence, the intersection between vulnerability to climate change and broader institutional and socio-economic fragility can increase the potential for conflict. This new trend has been referred to as the "climate-conflict nexus" and is characterized by intersection between two key factors: weak institutions and pre-existing social fragility, as well as climate change vulnerability[102]. This combination is of concern; countries that are most vulnerable to climate change are often the poorest or most fragile. Where governments are not equipped to manage the impacts of climate change, conflict risks can increase. Noting that agriculture accounts for around 70 percent of water used in the world today, in the context of climate change, access to water is expected to become both increasingly valued and contested, and hence a conflict risk in environments characterized by weak institutions.

[102] OCHA. 2016. *Understanding the climate-conflict nexus from a humanitarian perspective: a new quantitative approach*. New York. Available at: https://docs.unocha.org/sites/dms/Documents/OCHA_OP17_climate%20change_online.pdf.

Vulnerability and exposure of individuals and their communities to the effects of extreme events and other natural disasters depends on a range of economic and social factors, gender, age, socio-economic status and ethnicity[103].

In addition to increasing challenges resulting from climate change, there are a growing number of interrelated longer-term issues which can impact, or be impacted by, the prevalence of conflict, such as urbanization and rural transformation, and implications for resource availability, agricultural productivity, and food security and nutrition overall. Where institutions – both rural and urban – are not equipped to manage fluctuating populations together with resource allocation and provision of services, the potential for conflict can increase.

These critical issues are increasingly interconnected. Demographic shifts and resource scarcity continue to create enormous development and political challenges, as do threats emanating from rapid urbanization and climate change. The world is expected to go from 7 billion people to more than 9 billion by 2050. This will add to already tremendous stresses on infrastructure and resources, as well as increase a vulnerable pool of disaffected youth.

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

In the context of the increased complexity of human-made and natural crises, protracted displacement, overstretched financial of the humanitarian section, development and humanitarian actors are joining forces to find innovative approaches to effectively address these needs. Scaling-up cash-based programming and risk-informed social protection systems can critically strengthen resilience. Access to predictable, sizable and regular social protection benefits can, in the short-term, protect poor households from the impacts of shocks, including erosion of productive assets, and can minimize negative coping practices. In the longer term social protection can help to build capacity, smoothing consumption, and allowing for investments that contribute to building resilience of people to future threats and crisis. Strengthening the capacity of national and sub-national actors to development social protection systems that are risk-informed and responsive to shocks are a key instrument to plan timely and efficient responses to emergencies.

7.3 The complex nexuses of conflicts

All in all, several trends in the domains of conflicts and natural disasters, raise challenges, specifically related to the entanglement of various factors and complex nexuses and cause-effect relationships. The entanglement of factors such as conflicts, food insecurity, climate change, natural resource degradation, displacement of people, distressed migrations, make it difficult to redress degraded socio-economic and environmental situations and call for prevention through equity, stability and peace building. Key nexuses are summarized here below.

[103] IPCC (2012): Managing the risks of extreme events and disasters to advance climate change adaptation. Special report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf

Climate change-conflict nexus. Climate change-related extreme weather events are expected to exacerbate a deepening global need for humanitarian assistance, including by contributing to conflict risks and associated pressure on populations to move. Whilst climate change *per se* is not necessarily associated with violence, the intersection between vulnerability to climate change and broader institutional and socio-economic fragility can increase the potential for conflict. This new trend has been referred to as the "climate-conflict nexus" and is characterized by intersection between two key factors: weak institutions and pre-existing social fragility, as well as climate change vulnerability[104]. There is an expectation that disasters and conflict will coincide more in the future.

Agricultural transformation, resources and conflict-nexuses. In addition to increasing challenges resulting from climate change, there are a growing number of interrelated longer-term issues which can impact, or be impacted by, the prevalence of conflict, such as urbanization and rural transformation, and implications for resource availability, agricultural productivity, price fluctuations, financial shocks and food insecurity overall, may all shape – and complicate – future trends in the disaster–conflict interface and negatively Where institutions – both rural and urban – are not equipped to manage fluctuating populations together with resource allocation and provision of services, the potential for conflict can increase.

Nexus between regional conflicts and global stability. A concerning trend is that the implications of conflict-induced food insecurity are no longer limited to specific countries or regions, but have global impacts. In 2015, over 65 million people worldwide were forcibly displaced, the highest number since the end of World War II. The proximate effects of today's conflicts are increasingly echoed across the broader global landscape as conflict-affected people move across and within countries, regions and continents in a bid to manage the risks and consequences of conflict. There is a deepening awareness of how food insecurity in one part of the world can influence social services, political systems and national security elsewhere.

***Equity and conflict prevention nexus*.** Fostering greater equity within and between countries and human rights is key to prevent conflicts. Equity in economic development and good governance, help address the root causes of armed conflict. The UN system needs to pull together in a more integrated and coherent manner, united in the service of preventing armed conflicts and crises, reducing risk, building resilience, and sustaining peace. A number of high-level reviews have stressed the centrality of conflict prevention, recognizing that preventing crises and sustaining peace are shared, Charter-based responsibilities across the entire UN system. Sustaining peace must be clearly embedded in the next 2016 quadrennial comprehensive policy review (QCPR) of the UN System.

Focus of FAO's work on building sustainable peace, equity and stability. Without adequate focus of all FAO's work on coherently building sustainable peace, equity and stability in the short and long term, FAO is likely to result much less effective in achieving its objectives. Although FAO has developed considerable expertise working on, in, and through conflicts, and these experiences provide a foundation for enhanced engagements by FAO and its partners, it is important to recognise that conflict-sensitive approaches, i.e. shaped to contribute to conflict prevention, sustain peace, stability and equity, are needed not only for humanitarian assistance but especially for development support, particularly in the light of SDG16. This approach challenges the whole organization to scrutinize its approach to development and related field

[104] OCHA. 2016. *Understanding the climate-conflict nexus from a humanitarian perspective: a new quantitative approach*. New York. Available at: https://docs.unocha.org/sites/dms/Documents/OCHA_OP17_climate%20change_online.pdf.

interventions through the lens of building sustainable peace, equity and stability. This would allow identifying conducive and unconducive approaches and adjusting accordingly.

Focus on reducing and managing disaster risks. Missing to embed disaster risk reduction (DRR) and management (DRM) into development plans and related investment, results in ineffective interventions, particularly in countries facing recurrent disasters and where agriculture is a critical source of livelihoods, food security and nutrition, as well as a key driver of economic growth. As climate change intensifies risks from natural hazards, DRR must be made an urgent priority in these countries if the world is to deliver the Sustainable Development Goals (SDGs). This is a missed opportunity. In the top 30 fragile states, for every USD 100 of emergency aid spent after an event, just USD 1.30 is spent to prevent disaster and reduce its impacts, should it occur. This is despite the fact that 58 percent of disaster-related casualties take place in the world's top 30 fragile states[105]. DRR is also an entry point for climate change adaptation and resilience building. Opportunities that exists through climate financing need to be geared at the national level and establish strong linkages between DRR and Climate Change Adaptation.

Data gaps on conflicts and natural disasters. Challenges arise when working on conflicts, natural disaster and related causes and impacts because there are number of gaps in relation to availability of and access to data and information, including gender-disaggregated ones. Furthermore, there is no single harmonized methodology available to collect data on causes and impacts of conflicts and natural disasters, specifically on the agriculture sector. Data collection, monitoring and reporting on the impact of crises at the national and sub-national level should be improved and harmonized across countries, to better inform resilient and sustainable development planning.

7.4 Impacts on food security – food chain crises

The human food chain is under continued threat from an alarming increase in the number of outbreaks of transboundary animal and plant pests and diseases, as well as food safety and radiation events. Avian influenza, foot and mouth disease, *peste des petits ruminants*, locust infestations, wheat, cassava, maize and banana diseases, forest pests and diseases, aquatic diseases, food-borne pathogens and mycotoxins are just some examples of threats to the human food chain that have detrimental effects on food security, human health, livelihoods, national economies and global markets. Climate change is in part responsible for food chain emergencies.

While there is clear evidence that climate change is altering the distribution of animal and plant pests and diseases, the full effects are difficult to predict. Changes in temperature, moisture and atmospheric gases can fuel growth and generation rates of plants, fungi and insects, altering the interactions between pests, their natural enemies and their hosts. Changes in land cover, such as deforestation or desertification, can make remaining plants and animals increasingly vulnerable to pests and diseases. Some of the most dramatic effects of climate change on transboundary animal diseases are likely to be seen among insect vectors, like mosquitoes, midges, ticks, fleas and sandflies, and the viruses they carry. With changes in temperatures and humidity levels, the populations of these insects may expand their geographic range, and expose animals and humans to diseases to which they have no natural immunity. For example, climatic

[105] ODI Briefing. 2016. *When disasters and conflicts collide: facts and figures.* Available at: https://www.odi.org/sites/odi.org.uk/files/resource-documents/10537.pdf

changes could influence the risk of disease emergence, transmission and spread of Rift Valley fever – a zoonotic, viral and vector‑borne disease representing a threat to human health, animal health and livestock production.

7.5 Animal transboundary diseases: cases and causes.

Transboundary animal diseases (TADs) are highly contagious epidemic diseases that can spread extremely rapidly, irrespective of national borders. They cause high rates of death and illness in animals. The occurrence of TADs have serious socio-economic consequences (e.g. disruption of international and regional livestock market/trade), constitutes a constant threat to livelihood of livestock farmers both in developed and more severely in low and middle-income countries, threatens food security and prevents animal husbandry sectors from achieving their economic potential.

Factors that drive the emergence and spread of endemic and zoonotic diseases are also implicated in the dynamics of TADs; lack of access to goods and services in areas stricken by poverty and hunger, political instability and disruption of veterinary services, trade of livestock and of products of animal origin are additional drivers more linked or more specific to TAD's spread. A good example is the situation of lumpy skin disease, a disease that traditionally was observed in Africa, is spreading quickly to Middle East and Asia, and most recently (2015/2016) into Europe (Alkhamis and Van der Waal, 2016)[106]. Poorly regulated movements of high numbers of animals and climatic seasonal fluctuation of populations of arthropod mechanical transmitters represent a risk of disease spread (FAO, 2015)[107].

Another highly contagious disease is the Foot-and-Mouth Disease (FMD) affecting many countries in Africa, Asia and Middle East. Over 100 countries are not FMD-free and these infected countries remain a permanent threat to disease free countries. FMD affects livestock trade, access to regional, and international livestock market development. The last epidemic episode started in 1990 in South-East Asia, spread into far East Asian countries (Knowles *et al*., 2001)[108] and in 11 years the disease travelled from Asia throughout the so-called "Eurasian ruminant street", most likely due to uncontrolled animal movements, to arrive in Europe in 2001 (France and United Kingdom of Great Britain and Northern Ireland) (Mahy, 2005)[109]. In the United Kingdom of Great Britain and Northern Ireland alone, the economic impact of FMD was estimated at USD14 billion[110].

Following the successful campaign of rinderpest eradication (the disease was officially declared eradicated in June 2011 jointly by FAO and OIE), FAO, in collaboration with OIE, launched in 2015 the Global Strategy for the Control and Eradication of the *peste des petits ruminants*

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[106] Alkhamis, M.A., Van der Waal, K. (2016). Spatial and Temporal Epidemiology of Lumpy Skin Disease in the Middle East, 2012- 2015. Front. Vet. Sci., 3: 19 (doi: 10.3389/fvets.2016.00019).

[107] FAO (2015). Emergence of lumpy skin disease (LSD) in Europe. EMPRES Watch, Vol. 33, September 2015, FAO, Rome.

[108] Knowles, N.J., Samuel, A.R., Davies, P.R., Kitching, R.P., Donaldson, A.I. (2001). Outbreak of foot-and-mouth disease virus serotype O in the UK caused by a pandemic strain. Vet. Rec., 148(9): 258-259.

[109] Mahy, B.W. (2005). Introduction and history of foot-and-mouth disease virus. Curr. Top. Microbiol. Immunol., 288: 1-8.

[110] FootAndMouthDiseaseInfo.org – Fact Sheet: Industry Economics (http://www.footandmouthdiseaseinfo.org/factsheetindustryeconomics.aspx

(PPR) (OIE and FAO, 2015)[111]. The disease severely affects small ruminants in almost 70 countries in Africa, the Middle East and parts of Asia. It is highly contagious and causes USD1.5 to 2 billion losses each year in regions that are home to over 80 percent of the world's sheep and goats and to more than 330 million of the world's poorest people, many of whom depend on them for their livelihoods.

Several other TADs, such as African swine fever in pigs (FAO, 2013; Gallardo *et al*., 2015)[112], Newcastle disease (Ashraf and Shah, 2014)[113] in poultry, Contagious Bovine Pleuropneumonia in cattle in Africa and Classical Swine fever, highly impact the animal industry, mainly in low income countries, and regional and international livestock market worldwide with severe repercussions on global food security and food availability, and, due to reduced income from the livestock-agriculture industry, food affordability.

Actions needed to address TAD. Priority consideration should be addressed to preventing incursion, establishment and spread of disease agents and promote healthy livestock agriculture. Healthy livestock is the necessary, crucial prerequisite for building and achieving sustainable production of nutritious and accessible food for everyone. The Animal Health Service of FAO has the largest animal health programme in the world. However, given the magnitude of the disease problem, its entomological, veterinary, medical, public health and environmental dimensions, not a single specialized agency can cope with all the aspects that need to be addressed to understand the risks, and prevent, control and eliminate/eradicate the disease. Major international coordination is needed to develop and implement collective global health protection strategies under the umbrella of the One Health concept (FAO, 2011)[114].

Uprising trends in transboundary plant pests and diseases. Ongoing climate change is in part responsible for a rise in transboundary plant pests and diseases and is modifying the dynamic of pests, e.g. locust populations, with risks for food insecurity particularly expanding in some remote areas prone to pests. Climate change is creating new ecological niches for the (re)emergence and spread of pests and diseases. Controlling transboundary plant pests and diseases is a major aspect of plant production productivity as this enables reducing yield losses of crops and pastures.

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

Emerging health-environmentally friendly technologies to control transboundary pests. The control of pests and diseases cannot be disjointed by protecting natural resources. This implies reducing the use of chemical pesticides by replacing them with bio-pesticides, to reduce human health and environmental impacts; adopting integrated production and pest management systems using an agro-ecosystems approach improving cropping systems for controlling plant

[111] OIE and FAO (2015). Global Strategy for the control and eradication of PPR (88 pp). FAO ISBN 978-92-5-108733-6 (available at http://www.fao.org/3/a-i4460e.pdf).

[112] FAO (2013). Report: The global platform for African swine fever and other important diseases of swine. FAO, Rome, Italy 5-7 November 2013 (available at: http://www.fao.org/3/a-i3739e.pdf)

Gallardo, C., de la Torre Reoyo, A., Fernández-Pinero, Iglesias, I., Jesús Muñoz, M., Arias, M.A. (2015). African swine fever: a global view of the current challenge. Porcine Health management, 1: 21 (https://porcinehealthmanagement.biomedcentral.com/articles/10.1186/s40813-015-0013-y, DOI: 10.1186/s40813-015-0013-y).

[113] Ashraf, A., Shah, M.S. (2014). Newcastle Disease: Present status and future challenges for developing countries. Afric. J. Microbiol. Res., Vol. 8(5): 411-416.

[114] FAO (2011). ONE HEALTH: Strategic Action Plan http://www.fao.org/docrep/014/al868e/al868e00.pdf

pests and diseases; adopt Robust/resistant varieties to plant pests and diseases in the context of climate change.

Prevention strategies to reduce the risk of plants pests and diseases to occur (reduce their likelihood of occurrence and impact) are also needed, such as pursuing the development and improvement of information systems for early warning and rapid response to prevent pest invasions into cropping areas, also through mobile phones and drones for pest (e.g., locust) surveillance and control in remote areas.

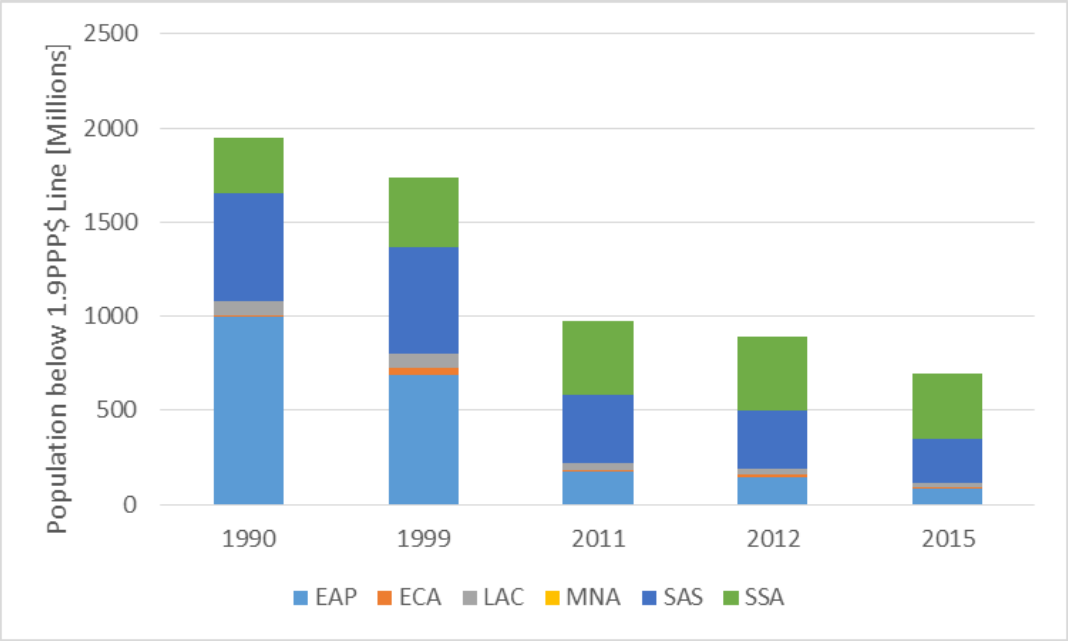
8 Poverty, inequality and food security

Changes in population number, location and structure, shifts in income levels , as well as modifications of technological processes economy-wide and within food systems, including primary agricultural production, are likely to affect entitlements to income, earning opportunities through paid jobs and self-employment, remuneration of capital and natural resources. These changes are likely to affect poverty, inequality and food security in all its dimensions, and hence also the prevalence of undernourishment and other forms of malnutrition.

8.1 Poverty

Extreme poverty, measured in terms of number of people living below the recently updated poverty line of 1.9 US$/day expressed in Purchasing Power Parity (PPP), has declined since 1990 (Figure 8.1), however, more than 700 million people still live in extreme poverty. This decline has been particularly significant in the East Asia-Pacific but extreme poverty is particularly persistent in Sub-Saharan Africa.

Figure 8.1 Number of people living below the poverty line of 1.9 USD/day PPP.

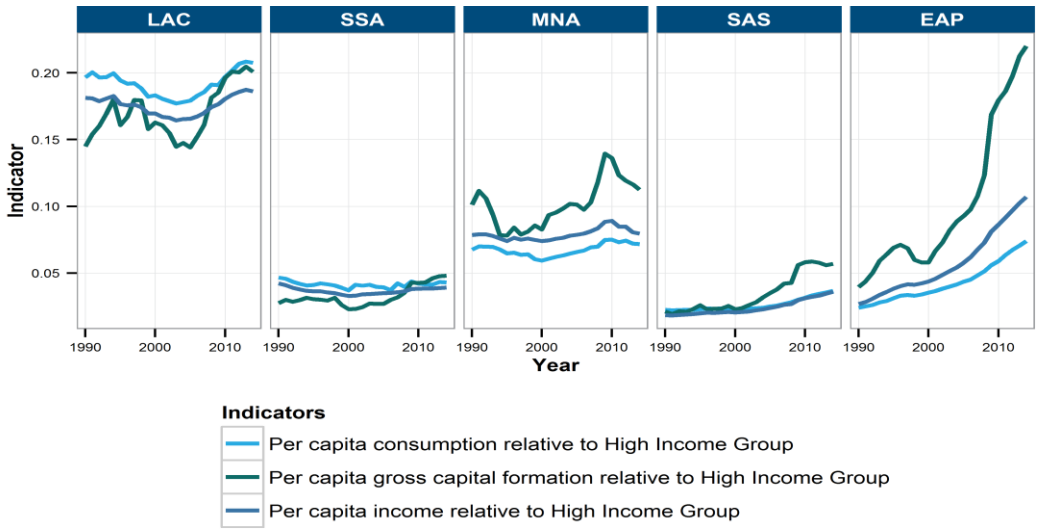


Source: FAO GPS elaborations based on World Bank database PovCalNet, as reported in Global monitoring Report 2015/2016. http://www.worldbank.org/en/publication/global-monitoring-report/poverty-forecasts-2015

8.2 Trends and projections in between-country income inequality

Looking at recent trends, convergence in income per capita, consumption and gross capital formation between low-income countries and high-income countries is barely ongoing. Figure 6.1 shows the ratio of per capita consumption in the various low-income regions relative to per capita consumption in high income countries. While per capita consumption in LAC was 20% of per capita consumption in High-Income countries in 1990, after 25 years it is barely above 20%. In SSA the situation is even worse: per capita consumption was below the 5% of the one in High income countries and after 25 years is still as such. Analogous trends apply to per capita capital formation, signaling, even in a future perspective, a relative weakness of capital endowment to revert this situation. Only East Asia, and to a much lesser extent South Asia, show some clear signals in the direction of convergence.

Figure 8.2 Economic convergence: comparison of low income and high income countries

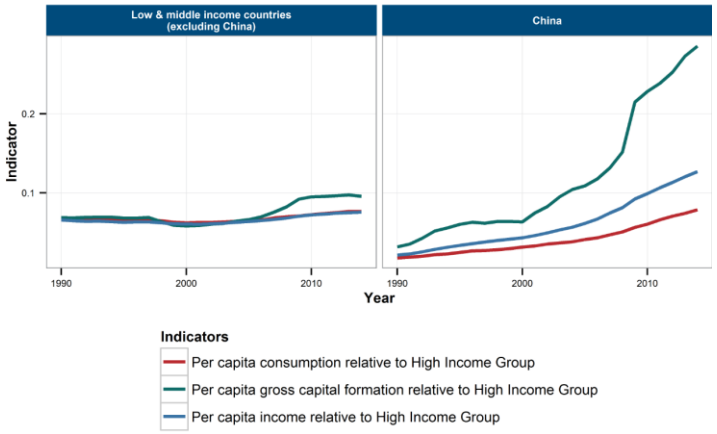


Source: Elaborations of the FAO Global Perspectives (GPS) Team on UN Data from the System of National Accounts (2016) – Main Aggregates, in constant 2005 US$.

All in all, in the last twenty-five years, per capita gross capital formation in low and middle income countries, excluding China, barely reaches the 10% of per capita gross capital formation in high-income countries. Only China, since the beginning of the century displays significantly increasing per capita capital formation, which is recently getting closer to 30% of that of rich countries (Figure 8.2 and 8.2a).

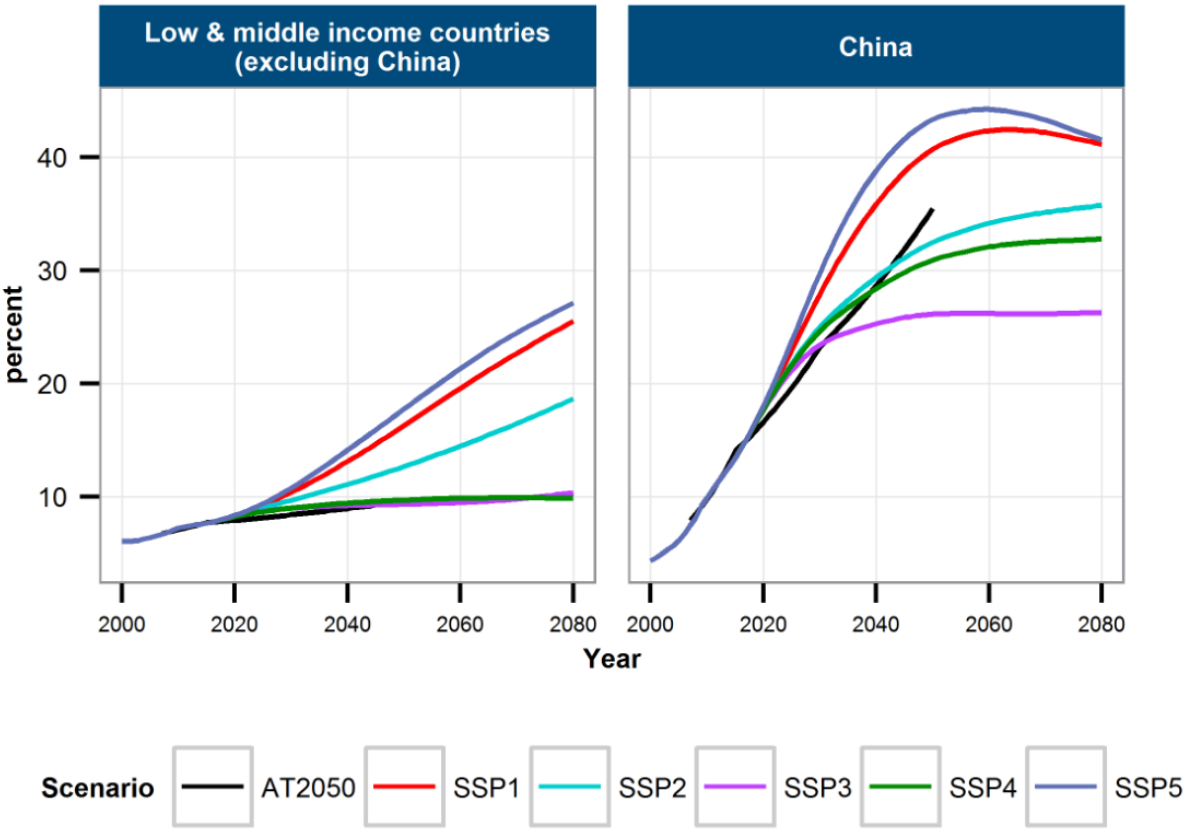
Recent GDP projection reflecting alternative possible futures (Shared Socio-economic Pathways –SSPs) were carried out by OECD and IIASA in the context of climate change analyses for the fifth assessment report (AR5) of the IPCC. Some of them are more optimistic than the ones assumed by FAO. However, even under the most optimistic scenario, and not before 2080, the per capita income of low, middle -income countries (apart from China) would not reach 30% of the per capita income of high income countries (Figure 8.4). More conservative estimates of p.c. GDP growth in low, middle-income countries assumed in the AT2050, would not exceed 10% of the high-income countries, apart from China, which was projected to achieve 35%.

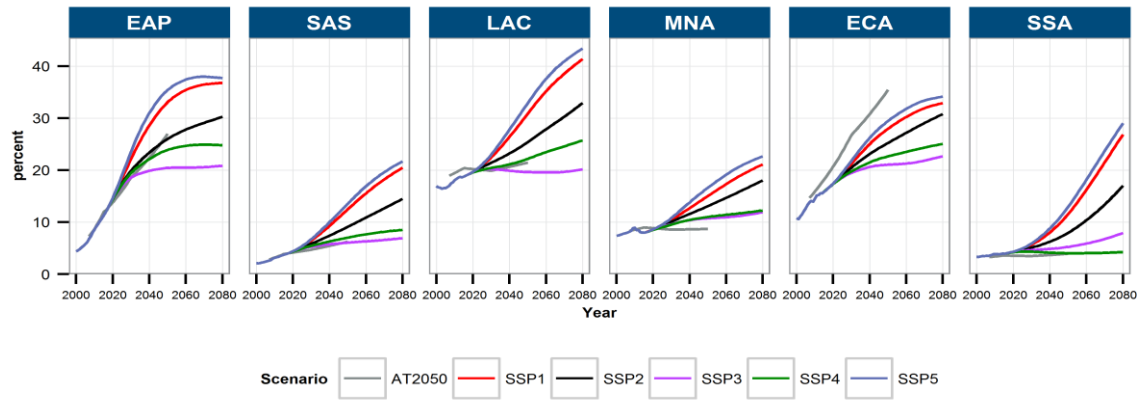
Figure 8.2a Per capita indicators of low and middle-income relative to high-income countries



Source FAO Global Perspectives Studies. Unpublished. Based on System of National Accounts (SNA) -Main Aggregates http://unstats.un.org/unsd/nationalaccount/sna.asp

Figure 8.3 GDP per capita projections in low-income countries a share of High income ones





Source: Elaborations of the FAO Global Perspectives Studies (GPS) Team on OECD-IIASA Data from Shared Socio-Economic Pathways (SSP) database and AT2050.

8.3 Undernourishment – past and present

The 2015 State of Food Insecurity in the World (SOFI) of the FAO pegs the total number of persons who are not able to acquire enough food to meet the daily minimum dietary energy requirements, over a period of one year, in the low-income countries at 780 million in 2014/16 (Table 8.1), or 12.9 percent of their population (7.3), with average food energy supply at 2620 kcal/person/day.

The results presented in the 2015 issue of SOFI also suggest that actual progress made towards the WFS target fell far short of the original ambition. Between 1990/2 and 2005, the number of undernourished fell by less than 70 million. The significant achievements made in East Asia (mainly China) were compensated by slow or no progress in the other two regions with the high concentrations of undernourished, i.e. sub-Saharan Africa and South Asia.

Recently, between 2005 and 2015, greater more progress has been made, as the number of undernourished declined by 135 million; twice as much the decline achieved during 1990-2005. However, even if the recent acceleration would continue, this would still be insufficient to achieve the World Food Summit (WFS) target. When extrapolated into the future, and even assuming the faster pace of progress attained over the past 10 years, the target of eradicating hunger by 2030, as foreseen in Sustainable Development Goal (SDG) 2.1, would remain elusive.

Table 8.1: Number of undernourished, 1990/92-2015

	Number of undernourished (millions)						
Regions/sub-regions	**1990–92**	**2000–02**	**2005–07**	**2010–12**	**2014–16**	**Change**	**Progress towards WFS target**
World	1 010.6	929.6	942.3	820.7	794.6	–21.4	
Developed regions	20.0	21.2	15.4	15.7	14.7	–26.3	
Developing regions	990.7	908.4	926.9	805.0	779.9	–21.3	
Least-developed countries	209.3	244.3	237.6	237.8	250.9	19.9	▲
Landlocked developing countries	94.4	112.3	105.2	103.8	107.4	13.8	▲
Small Island Developing States	10.2	10.7	10.8	9.7	10.1	–0.5	◄►
Low-income economies	199.2	238.4	231.5	236.6	247.6	24.3	▲
Lower-middle-income economies	407.7	374.5	420.0	353.2	355.6	–12.8	◄►
Low-income food deficit countries	460.2	468.9	512.8	474.0	495.8	7.7	▲
FAO regions							
Africa	175.7	203.6	206.0	205.7	220.0	25.2	▲
Asia and the Pacific	726.2	617.2	645.3	525.4	490.1	–32.5	◄►
Europe and Central Asia	9.9	11.5	8.8	7.2	5.9	–40.3	◄►
Latin America and the Caribbean	66.1	60.3	47.1	38.3	34.3	–48.0	
Near East and North Africa	16.5	23.1	27.3	33.9	33.0	99.8	▲

Source: FAO. 2015. *The State of Food Insecurity in the World 2015*

Table 8.2: Proportion of undernourished, 1990/92-2015

	Proportion of undernourished (percent)					
Regions/sub-regions	**1990–92**	**2000–02**	**2005–07**	**2010–12**	**2014–16**	**Change so far**
World	18.6	14.9	14.3	11.8	10.9	–41.6
Developed regions	<5.0	<5.0	<5.0	<5.0	<5.0	n.a.
Developing regions	23.3	18.2	17.3	14.1	12.9	–44.5
Least-developed countries	40.0	36.5	31.4	27.7	26.7	–33.2
Landlocked developing countries	35.6	33.6	28.1	24.1	22.7	–36.1
Small Island Developing States	24.5	22.5	21.3	18.2	18.0	–26.3
Low-income economies	39.1	36.6	31.8	28.7	27.5	–29.7
Lower-middle-income economies	22.8	17.5	18.2	14.2	13.5	–40.7
Low-income food deficit countries	27.6	22.8	22.7	19.2	18.8	–32.0
FAO regions						
Africa	33.2	30	26.5	24.1	23.2	–30.1
Asia and the Pacific	24.3	18	17.8	13.7	12.3	–49.5
Europe and Central Asia	8.0	8.5	6.2	<5.0	<5.0	n.a.
Latin America and the Caribbean	14.7	11.4	8.4	6.4	5.5	–62.7
Near East and North Africa	6.6	7.5	8.1	8.3	7.5	14.6

Source: State of Food Insecurity in the World SOFI 2015

Progress in relative terms, that is, as a proportion of the total population, was more noticeable. The prevalence of undernourishment fell by 44.5 percent over the past 25 years from 23.3 percent to 12.9 percent in low-income countries (Table 8.2), not too far from the related Millennium Development Goal target (MDG 1c), which foresaw a halving of the share of undernourished. Some regions, such as Latin America, the east and south-eastern regions of Asia, the Caucasus and Central Asia, and the northern and western regions of Africa have made particularly fast progress. Progress was also recorded in southern Asia, Oceania, the Caribbean and southern and eastern Africa, but at too slow a pace to reach the MDG 1c.

While overall progress was driven by some very populous countries, it was by far not limited to these few. A total of 72 low-income countries out of 129, or more than half of the countries monitored, have reached the MDG 1c hunger target. Most enjoyed stable political conditions and economic growth, often accompanied by social protection policies targeted at vulnerable population groups.

8.4 Trends in food insecurity and hunger

Most recent FAO projections of undernourishment to 2030 provided in the report "Achieving Zero Hunger" (AZH, FAO-IFAD-WFP, 2015) [115] report figures of undernourishment under a "Business as Usual" scenario of 637 million people in low and middle income countries. (Table 8.4). These figures exceed by 95 million people, (+17.5%) previous projections to 2030 reported for a mostly overlapping set of "developing countries" in the FAO AT2050 report[116]. This signals that projections of undernourishment to 2030 in AT2050 may be quite optimistic. The optimism of AT 2050 is also confirmed when comparing at AT2050 projections to 2015 also reported figures for 2015 and 2050 (Table 6.4) SOFI 2015 reports undernourishment figures for 2015 of around 85 million people above the AT2050 projections for "developing" countries (+12.5%).

If, as an overall direction, a +15% over the AT2050 projections is taken for 2050, this would lead to around 370 million people still undernourished in low and middle income countries by 2050.

Table 8.4: Past and projected number of undernourished by region, comparison with recent estimates

	2005/07 base AT 2050	2015 Proj. AT2050	2015 SOFI 2015*	2030 projected AT2050	2030 Proj.AZH	2050 Proj. AT2050
Developing countries**	827	687	773.7	543	637	318
Excluding South Asia	*496*	*408*	505.2	*333*		*225*
Sub-Saharan Africa	201	195	220.1	180	216	119
Near East/North Africa	32	30	35.1	29	29	25
Latin America and the Caribbean	47	38	34.8	28	27	18
South Asia	331	216	268.5	211	188	93
East Asia	279	143	215.2	94	175	62
Transition and Industrial**			21.8		16	
World			795.5		653	

*The regional aggregates are not necessarily those published in SOFI 2015.

** In line with the definition of the regional aggregates used in AT2050. For AZH this refers to "low and middle-income countries" and "high-income" countries, respectively.

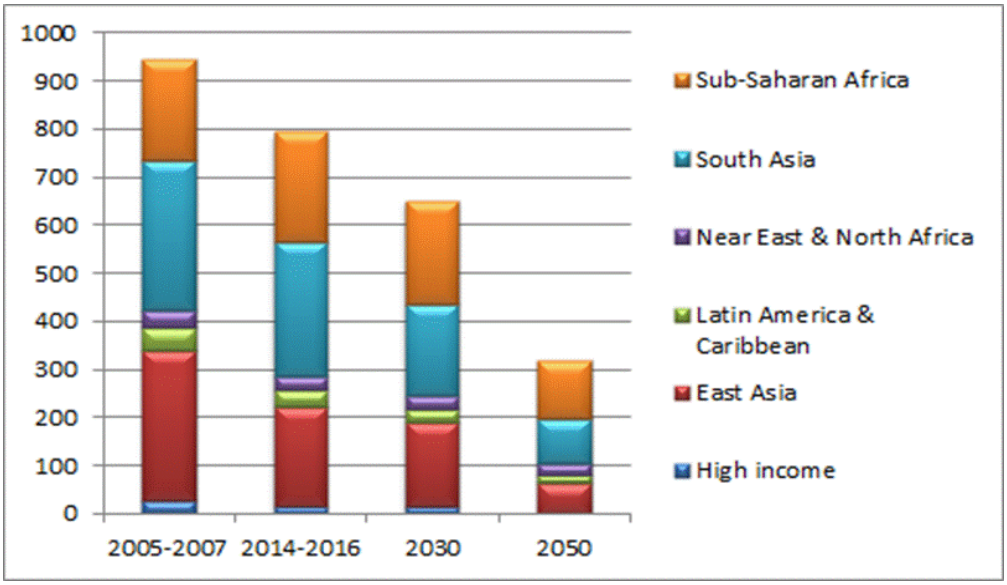
The projected number of undernourished in the 2015 FAO-IFAD-WFP report "Achieving Zero Hunger" would definitely fall short of SGD target 2.1 of reaching a complete eradication of hunger by 2030 (Figure 8.5). That is why FAO, IFAD and WFP call for a twin-track approach which merges investment in social protection, to immediately raise the consumption of

[115] FAO, IFAD and WFP. 2015. Achieving Zero Hunger: the critical role of investments in social protection and agriculture. Rome, FAO. http://www.fao.org/3/a-i4951e.pdf

[116] Nikos Alexandratos and Jelle Bruinsma, World Agriculture Towards 2030/2050, The 2012 Revision

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

Figure 8.5. Undernourishment in a "Business as Usual" Scenario (million people)



Sources: Years 1990-92 and 2014-16: State of Food Insecurity 2015. FAO UN –Rome, http://www.fao.org/publications/sofi/2014/en/ Year 2030: Achieving Zero Hunger: FAO UN, IFAD, WFP – Rome http://www.fao.org/3/a-i4951e.pdf. Year 2050: AT2050

Another correlate of progress towards MDG-1 identified in SOFI 2015 was the growing importance of social protection systems. Social protection directly contributes to the reduction of poverty, hunger and malnutrition by promoting income security and access to better nutrition, health care and education. The report "Achieving Zero Hunger" (FAO-IFAD-WFP, 2015) highlights the need to boost social protection programmes to achieve zero hunger by 2030, as complement to investment in pro-poor productive activities. By improving human capital and mitigating the impacts of shocks and crises, social protection fosters the ability of the poor to participate in growth through better access to employment. In view of the sometimes precarious economic situation in some countries that rely already on social safety nets, this add to the concerns of faster progress and makes the SDG goal of eradicating hunger even more elusive.

As a distinct group, rural women disproportionately experience poverty and exclusion. Globally, and with few exceptions, rural women fare worse than rural men and urban women and men on every gender and development indicator for which data are available[117]. Disproportionately, 60 percent of the undernourished are women, who make up 43 percent of the agricultural labour force and suffer deep discrimination and inequality in access to land and other resources and services. Alleviating their social marginalization and disproportionate poverty by addressing pervasive gender inequalities will reap multiple benefits by improving food security and in poverty reduction.

But not only woman in rural areas are a group at risk for poverty and undernourishment as poverty incidence is generally higher in rural areas. While it seems reasonable to assume that the same rural disadvantage applies in the case of undernourishment, there is also evidence to

[117] UNDESA /ESA/STAT/SER.K/19 The World's Women

the contrary (Ahmed et al 2007)[118], which suggests at least a more mixed picture with higher urban undernourishment rates in some cases: The authors use 20 country surveys conducted between 1004 and 2003 and sample sizes between 1800 and 119059 households. Lack of food access and availability in urban areas are reasons provided by the authors for the observed urban disadvantage in more than half of the cases. However, they also point to the likely prevalence of measurement error due to the fact that meals eaten away from home are more difficult to measure. While not conclusive, the study points at the need to take not only rural population but also rural-urban interactions into account when addressing poverty and undernourishment.

[118] Ahmed, A U, R V Hill, L C Smith, D M Wiesmann and T Frankenberger (2007), "The world's most deprived: characteristics and causes of extreme poverty and hunger", 2020 Vision for Food, Agriculture and the Environment Discussion Paper No 43, International Food Policy Research Institute (IFPRI), Washington DC.

9 Nutrition and health

Malnutrition comes in a number of forms and causes a wide range of serious health problems. The impacts of poor nutrition can be felt by pregnant women, babies and young children for their entire lives. Nutrition-related health problems put a substantial burden on national economies, hindering prospects for development. Around the world dietary patterns are changing. This has consequences not only for public health, but also for sustainable development. As production systems intensify and the climate changes, the threat of food-borne diseases increases.

9.1 Malnutrition remains a global health emergency.

Although chronic undernourishment is declining, in 2014-2016 around 800 million people, or almost 11 percent of the world's population, went hungry. Nearly half of the deaths among children under five are attributable to undernutrition[119]. However, undernourishment is only one form of malnutrition. Micronutrient deficiencies and overnutrition (excessive food intake) also cause serious health problems for millions of people. Different forms of malnutrition can co-exist within the same country, the same household and even the same individual. Among the effects of this 'triple burden' of malnutrition are stunting (low height for age), wasting (low weight for height), underweight (low weight for age in children), overweight and obesity[120].

Childhood stunting is a largely irreversible outcome of inadequate nutrition and repeated bouts of infection during the first years of a child's life. Stunting before the age of two years results in poorer cognitive and educational outcomes in later childhood and adolescence[3]. Between 1990 and 2014, the prevalence of stunting declined from 39.6 percent to 23.8 percent, and the number of stunted children fell from 255 million to 159 million. However, the rate of stunting is not declining fast enough, particularly in Africa, to reach the World Health Assembly target of a 40 percent reduction by 2025[121]. In 2010-2015, an estimated 24 percent of children under five were moderately or severely stunted and 8 percent were wasted; 16 percent of all newborns were underweight[122].

Every year, more than 2 billion people are affected by one or more micronutrient deficiencies[123]. In 2011, more than half a billion women between the ages of 15 and 49 suffered from iron deficiency anaemia. This form of malnutrition contributes to 20 percent of all maternal deaths[124], with about 50 000 women dying in childbirth each year due to a lack of iron[4]. Vitamin

[119]United Nations Inter-agency Group for Child Mortality Estimation.2014. *Levels & trends in child mortality: Report 2014*. (available at http://www.who.int/maternal_child_adolescent/documents/levels_trends_child_mortality_2014/en/)

[120]FAO. 2014. *The State of Food and Agriculture 2013: Food systems for better nutrition*. Rome. (available at http://www.fao.org/publications/sofa/2013/en/)

[121]WHO. 2014. *Global Nutrition Targets 2025*: Policy Brief Series. Geneva. (available at http://www.who.int/nutrition/global-target-2025/en/)

[122]UNICEF. The state of world's children 2016 Statistical Tables. (available at http://data.unicef.org/resources.html). Data at the national level refer to different years within the period 2010-15. The low birth weight data refer to the period 2009-2013. For more information see: UNICEF–WHO–World Bank Group joint child malnutrition estimates. Levels and trends in child malnutrition: Key findings of the 2015 edition (available at http://www.unicef.org/media/files/JME_2015_edition_Sept_2015.pdf)

[123]Micronutrient Initiative web site at: http://www.micronutrient.org

[124]WHO. Micronutrient deficiencies: iron deficiency anaemia. (available at http://www.who.int/nutrition/topics/ida/en/).

A deficiency is the leading cause of preventable blindness in children, causing an estimated 250 000 to 500 000 children to go blind every year. Half of these children die within a year of losing their sight[125]. An estimated 38 million babies are born with iodine deficiency, which is the most common cause of preventable brain damage[126]. Zinc deficiency affects about 30 per cent of the world's population.

The prevalence of overweight and obesity is increasing worldwide. People are now consuming more foods that are high in energy, fats, added sugars or salt, and many do not eat enough fruit, vegetables and dietary fibre. This 'nutrition transition' reflects the increased production of processed food, rapid urbanization and more sedentary lifestyles. In 2014, more than 39 percent of people 18 and over were overweight and, of these, 13 percent were obese[127]. Between 1990 and 2014, the prevalence of overweight and obesity among children under 5 years rose from 4.8 per cent to 6.1 percent[128]. If this trend continues, by 2025 the percentage of overweight or obese children under five years old will reach 11 percent (or 70 million children).

The early occurrence of these diseases can have serious consequences on children's future risk of non-communicable diseases.[129]Globally, 44 percent of diabetes cases, 23 percent of ischaemic heart disease and 7 to 41 percent of certain cancers are attributable to overweight and obesity[130]. Sixty-five percent of the world's population live in countries where overweight and obesity kill more people than underweight.[131]

The economic costs of malnutrition are immense, with billions of dollars lost due to losses in productivity and avoidable health care costs. By focusing on improving nutrition in pregnant women and children, particularly during the child's first 1 000 days, many public health problems can be prevented and many obstacles to sustainable development overcome.[132]

9.2 Changes in dietary patterns are also affecting public health.

Dietary patterns are not only a reflection of what people eat; they reflect complex social behaviours. Many factors need to be considered when undertaking initiatives (e.g. nutrition education) to encourage behavioural changes that can lead to healthier diets.

The Global Dietary Database uses household surveys to measure diets and food intake around the world. Their data divide food items and dietary components into two categories: 'healthy' foods (fruits, vegetables including legumes, nuts/seeds, whole grains, seafood) and 'unhealthy' foods (red meat; processed meats), based on their relative risk of contributing to cardiovascular disease, type 2 diabetes, stroke and cancer.

Although excessive consumption of meat and other livestock products can be unhealthy, it should be noted that these foods can provide not only high-quality protein but a variety of micronutrients that are difficult to obtain in adequate quantities from foods of plant origin alone.

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[125]WHO. Micronutrient deficiencies: vitamin A deficiency. (available at http://www.who.int/nutrition/topics/vad/en/)

[126]WHO. Micronutrient deficiencies: Iodine deficiency disorders. (available at www.who.int/nutrition/topics/idd/en/)

[127] FAO. 2014. *The State of Food and Agriculture 2013: Food systems for better nutrition*. Rome. (available at http://www.fao.org/publications/sofa/2013/en/)

[128] WHO. 2014. *Global Nutrition Targets 2025*: Policy Brief Series. Geneva. (available at http://www.who.int/nutrition/global-target-2025/en/)

[129]Park, M.H., Falconer, C., Viner, R.M., and Kinra, S. 2012. The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review. *Obesity Reviews*, 13(11): 985–1000.

[130]WHO. Micronutrient deficiencies: Iodine deficiency disorders. (available at www.who.int/nutrition/topics/idd/en/)

[131]WHO. Obesity and overweight. Factsheet No. 311 (available at http://who.int/mediacentre/factsheets/fs311/en/)

[132]1,000 days web site at http://thousanddays.org/.

They are sources of essential micronutrients such as iron, vitamin A, iodine and zinc. Vitamin B12 is only found in animal source foods.[133]

Worldwide, mean intakes of 'healthy' foods are substantially below current recommendations. There is substantial variation in food consumption patterns in different world regions.[134] Fruit consumption tends to increase from lower to higher income regions, whereas vegetable consumption declines. Consumption of fish is highest in Southeast Asia. Dairy product consumption is highest in North America and Europe.

Between 1990 and 2103, the global consumption of 'healthy' foods increased, with important differences among the food groups. For example, fruit consumption is increasing in all regions, but vegetable consumption is increasing only in some regions. Whole grain consumption is increasing mainly in Southeast Asia. Seafood consumption is declining in three out of seven regions.

In most regions, the consumption of 'unhealthy' foods has increased more than the consumption of 'healthy' foods. Middle-income countries show the greatest shift toward dietary patterns based on unhealthy foods.[135]In all regions, consumption of processed meat has increased. There has been an increase in the consumption of sugar-sweetened beverages in four out of seven regions, with the largest increase in North America. In East Asia red meat consumption has increased substantially, but it has declined in every other region. There are similar levels of red meat consumption in East Asia, Latin America, North America and the EU15.[136]

For a broad picture on trends in food consumption, it is useful to look at statistics of per capita daily food availability. Of particular importance is the dietary energy supply (DES) reported in FAO's food balance sheets, which provides globally comparable indicators[137]. A DES analysis by food groups reveals that in the last fifty years per capita caloric availability has increased, as has the diversity of foods consumed (see figure 7.1a). Between 1961 and 2011, the daily share of per capita calories from cereals dropped from 35 to 29 percent in low- and middle-income countries and from 56 to 50 percent in high-income countries. During the same period, the share of calories from fruits and vegetables rose from 4.9 to 5.4 percent in high-income countries and from 3.9 to 6.9 percent in low- and middle-income countries.

While FAO projects these trends to continue, it is expected that between 2030-50 the availability of fruits and vegetables in low- and middle-income countries will fall below current levels, although they will remain well above 1961 levels. The DES in low- and middle-income countries is persistently lower than in high-income countries, but the gap is slowly closing. In 1961, the DES of low- and middle-income countries was only 68 percent of the DES in high-income countries, but rose to 81 percent in 2011. By 2050, it is projected to be 86 percent. It is interesting to note however, that, when looking at the groups of food items, the dietary patterns

[133]WHO. Healthy diet. Factsheet No. 394 (available athttp://www.who.int/mediacentre/factsheets/fs394/en/, accessed July 2016).

[134] Based on: Master, W. 2016. *Assessment of Current Diets: Recent Trends by Income and Region*. Working paper No 4. Friedman School of Nutrition Science and Policy and Department of Economics. Tufts University, using data provided by the Global Dietary Database (http://www.globaldietarydatabase.org/the-global-dietary-database-measuring-diet-worldwide.html.)

[135] Imamura, F. *et al.*, 2015. Dietary quality among men and women in 187 countries in 1990 and 2010: a systematic assessment. *The Lancet Global Health*, 3, e132–e142.

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

[137] Food availability is calculated from FAO food balance sheets, which provide a picture of national food availability by taking total production of different commodities and adjusting these for imports, exports and wastage, and then estimating average per capita food availability.

in the two groups of countries tend to converge (the ratios in the third panel of figure 7.1a are progressively getting closer to 1).

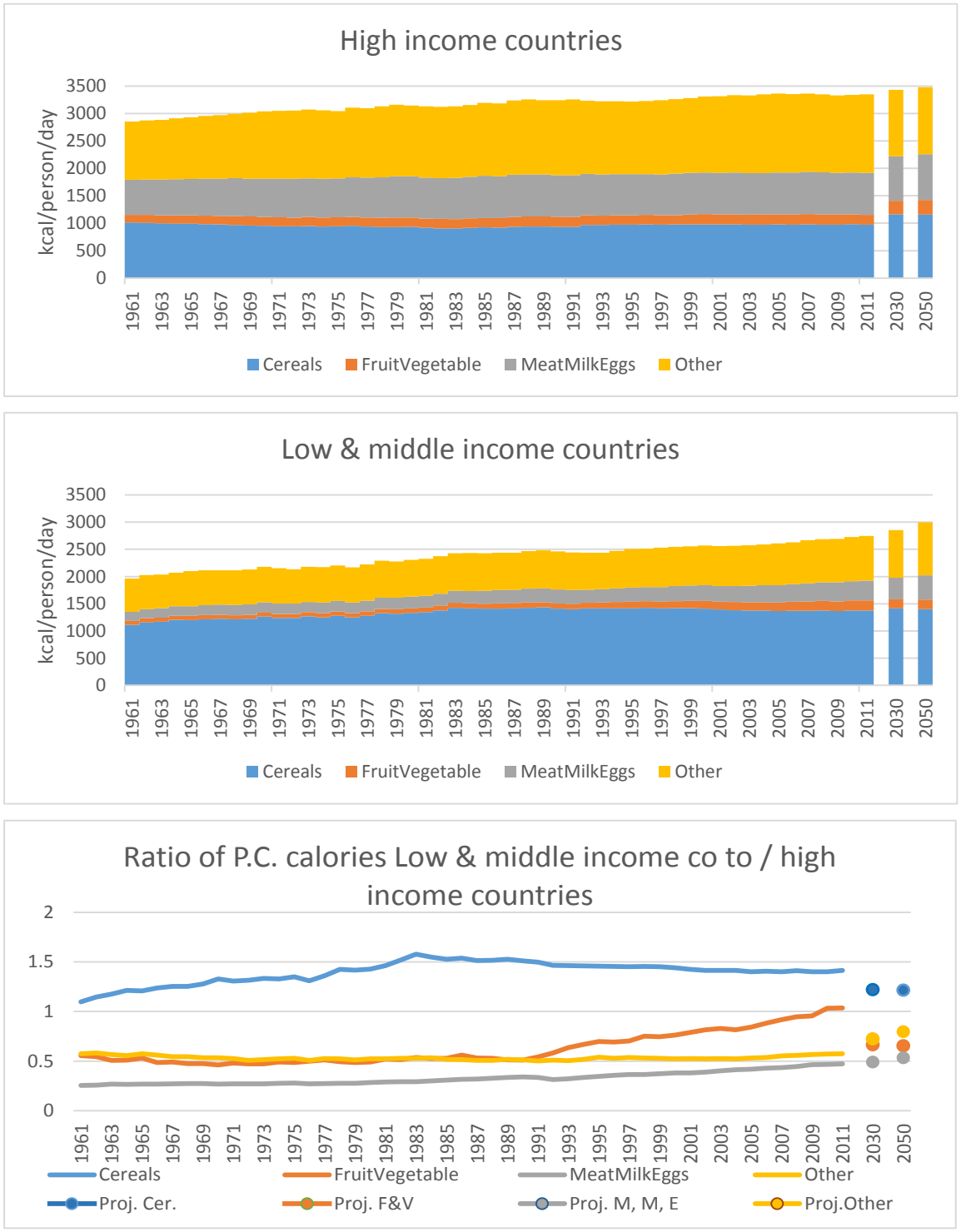
The DES analysis by food groups also reveals the evolution of available proteins in diets. In the last fifty years, in high-income countries, there has been an increase the daily intake of protein, particularly protein from animal products (meat, eggs, milk and dairy products), which rose from 39 g per person in 1961 to 52 in 2011. This represents a 33percent increase; an annual growth rate of around 0.6percent. Most of this increase occurred in the sixties and seventies. Since the mid-eighties, the protein intake from animal sources has remained almost constant. FAO projections for 2030 and 2050 show daily protein intakes of 54 and 57 g per person respectively (figure 9.1a). Between 1961 and 2011, in low- and middle-income countries, the daily per capita availability of protein from animal products rose from 9 to 20 g; a 116 percent increase or an average annual growth rate of 1.56 percent. The daily per capita protein intake from animal products in low- and middle-income countries is projected to reach 22 g by 2030 and 25 g by 2050 (figure 9.1b).

Globally, fish contribute around18 percent of the total animal protein intake, but in some coastal communities and small island states the percentage can reach as high as 60 percent[138]. Global per capita consumption of seafood has been increasing, currently exceeding 20 kg per year. This trend is expected to continue as incomes rise and consumers become more aware that fish and fishery products can be a healthy alternative to meat from farm animals.

There is growing recognition that nutrition is critical to achieving the post-2015 Sustainable Development Goals. Dietary patterns are now being considered not only for their impact on health, but for their contribution to environmental sustainability, particularly regarding climate change.

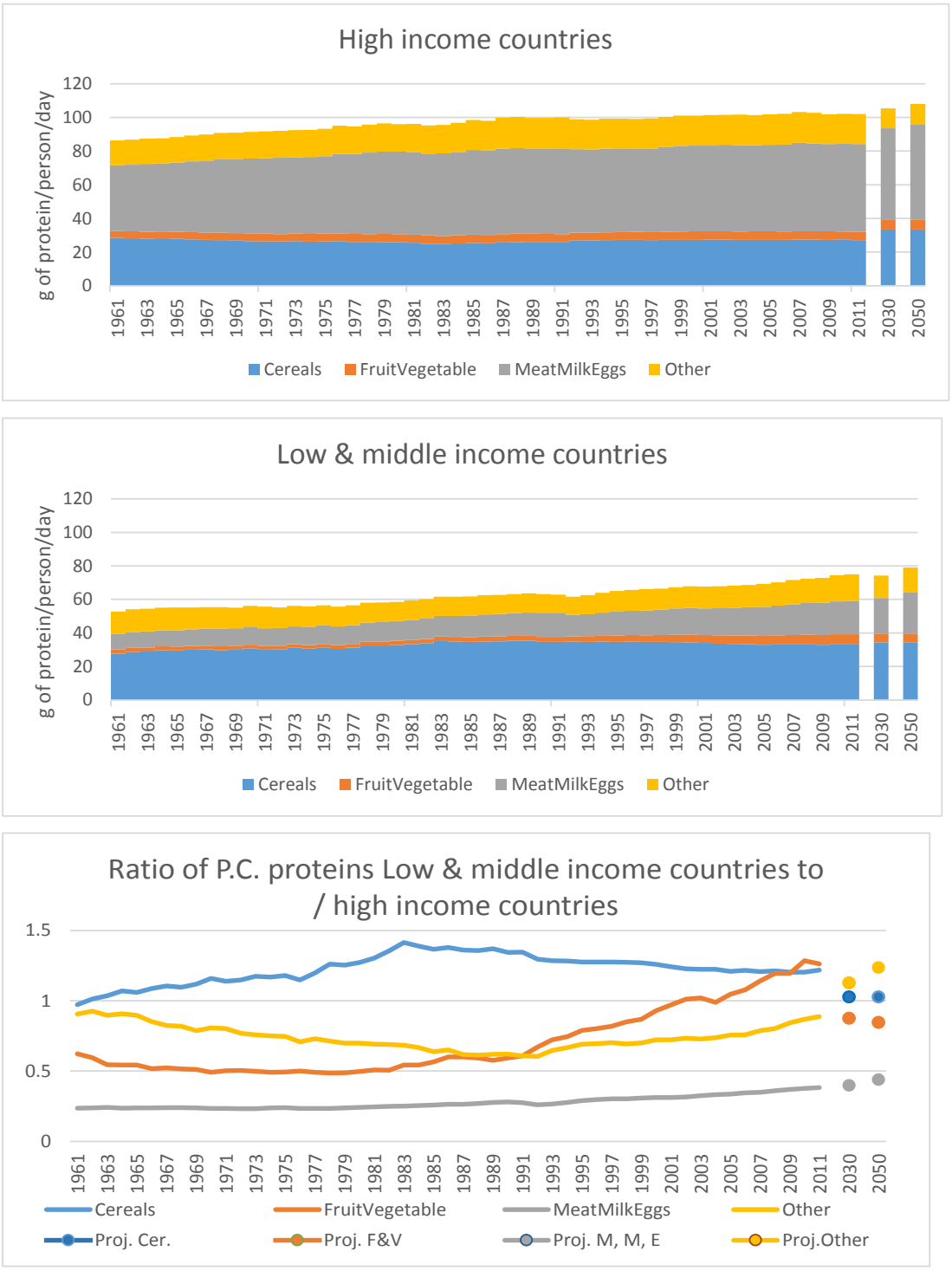
[138]FAO. High Level Expert Forum. Global Agriculture towards 2050. (available at http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf)

Figure 9.1a Per capita calories intake per source: trends and projections



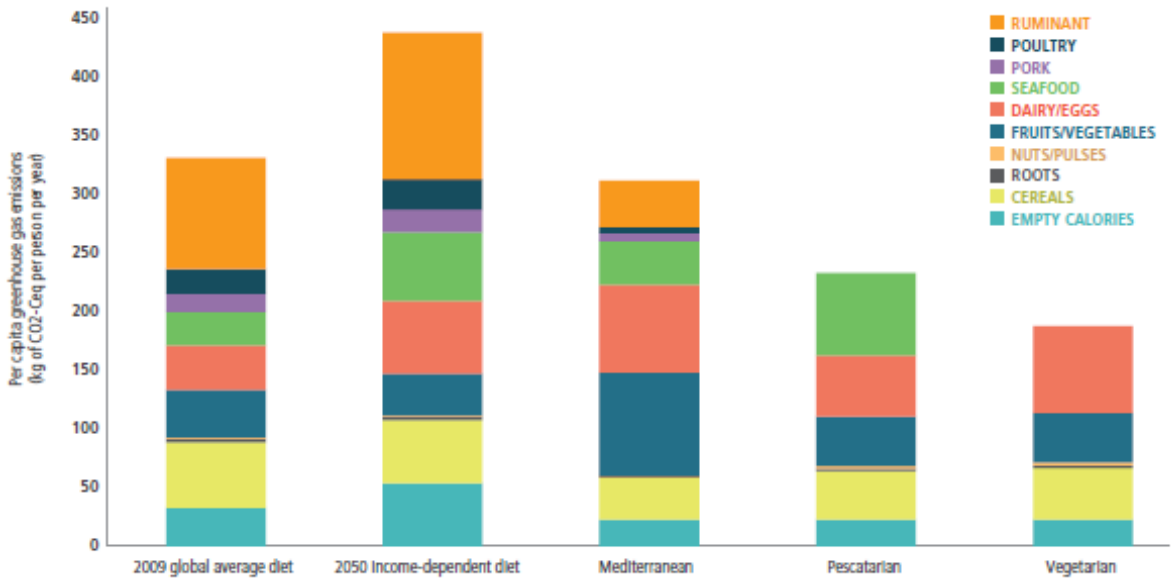
Sources: FAO Global Perspectives Studies. Years 1961-2011: FAOSTAT. Years 2030 and 2050 (projections): AT2050

Figure 9.1b Per capita protein intake per source: trends and projections



Sources: FAO Global Perspectives Studies. Years 1961-2011: FAOSTAT. Years 2030 and 2050 (projections): AT2050

Figure 9.2 Effects of diet type on GHG emissions



Source: International Food Policy Research Institute. 2015. Global Nutrition Report 2015 (Reproduced from Tilman, D. and Clark, M. 2014. Global diets link environmental sustainability and human health. *Nature*, 515 (7528): 518–522

Diets high in meat, particularly from ruminants, such as cattle, are associated with higher environmental costs and higher GHG emissions as methane is emitted from enteric fermentation, $CO_2$is released from the clearing of forests for pasture and nitrous oxide is generated from feed production[139] (Figure 9.2). Industrialized livestock systems tend to generate fewer GHG emissions per unit of product, but they have other significant social and environmental impacts, including: more withdrawals of freshwater resources, more pollution, more use of antibiotics (with the associated risks of increased antibiotic resistance) and potentially more outbreaks of zoonotic diseases. In terms of GHGs emitted per unit of product, the aquaculture sector has significant advantages over other food production systems, especially livestock. Increasing evidence suggests that dietary patterns that have low environmental impacts can be consistent with good health.[140]National dietary guidelines recommending lower red meat consumption, particularly among high-consuming groups, could help significantly reduce GHG emissions.[141]

Dietary patterns can affect climate change, and in turn climate change will also have an effect on food quality and nutrition. For example, the elevated levels of CO_2 emissions that are likely to be reached by 2050 are associated with substantial declines in the zinc, iron, and protein content of wheat, rice, field peas, and soybeans. In addition, higher temperatures and more

[139]FAO. 2013. *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities*. Rome. (available athttp://www.fao.org/docrep/018/i3437e/i3437e00.htm)

[140]FAO and the University of Oxford.2016. *Plates, pyramids, planet. Developments in national healthy and sustainable dietary guidelines: a state of play assessment*. Rome. (available at http://www.fao.org/documents/card/en/c/d8dfeaf1-f859-4191-954f-e8e1388cd0b7/)

[141]International Food Policy Research Institute (IFPRI). 2015. *Global Nutrition Report 2015: Actions and accountability to advance nutrition and sustainable development*. Washington, DC. (available at http://dx.doi.org/10.2499/9780896298835).

extreme weather events associated with climate change create favourable environments for food-borne pathogens[142].

9.3 Unsafe food remains a major cause of disease and death.

However, detailed data are lacking on the extent of food-borne pathogens.[143]Factors that contribute to outbreaks of food-borne diseases include: unsafe water used in food cleaning and processing; poor production processes and handling, including inappropriate use of agricultural chemicals; the absence of adequate storage infrastructure; and inadequate or poorly enforced regulatory standards.[144]

Food-borne diseases fall into four main categories: bacteria (e.g. Listeria, Brucella, Cholera); viruses (e.g. Hepatitis A); parasites (e.g. Toxoplasmosis, tapeworm, Chinese liver fluke); and chemicals and toxins (e.g. aflatoxins); cyanide from inappropriately processed cassava; peanut allergen; and dioxins. The burden of aflatoxins is especially high in Africa, Southeast Asia and Western Pacific. Aflatoxins, which can cause liver cancer, are produced by mould that grows on inappropriately stored grains, such as maize, as well as groundnuts, oilseeds and tree nuts. Aflatoxins have also been linked to stunting in children.[145]

Food-borne pathogens weaken immune systems. The most vulnerable groups are infants and young children, pregnant women, the elderly and people whose immune system is already compromised. In malnourished infants and children, food-borne diseases, which reduce the body's ability to absorb nutrients, contribute to malnutrition. Children who survive may suffer from delayed physical and mental development, depriving them of the opportunity to reach their full potential in society. Estimates of the impact of food-borne diseases in terms of Disability Adjusted Life Years (DALYs) is 33 million years. Forty percent of this burden is borne by children under 5 years of age. Africa suffers the highest burden, followed by Southeast Asia and the Eastern Mediterranean.[13]

As livestock production intensifies, incidences of food-borne diseases rise. Low-income countries develop partly by adopting intensive animal husbandry practices to maximize production, which increases the prevalence of pathogens in flocks and herds. Also, the warmer climate in tropical countries is conducive to the spread of naturally occurring toxins and parasitic diseases.

Food-borne diseases slow national economic development, hindering the growth of the tourist industry, the agricultural sector and food exports. Low-income countries' access to food export markets can be blocked by their inability to meet the international regulatory requirements set by the Agreement on the Application of Sanitary and Phytosanitary Measures of the World Trade Organization.[13] This can reduce incomes of smallholder producers, which can have an indirect effect on their capacity to buy nutritious food. Trade restrictions can also limit the

[142]International Food Policy Research Institute. 2015. Global Nutrition Report 2015: Actions and accountability to advance nutrition and sustainable development. Washington, DC. http://dx.doi.org/10.2499/9780896298835.

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

[144] Based on WHO Estimates of the Global Burden of Foodborne Diseases (available at http://www.who.int/foodsafety/areas_work/foodborne-diseases/ferg/en/)

[145]Partnership for Aflatoxin Control in Africa (PACA). The Relationship between aflatoxins and stunting: a summary of current research. Policy Brief. (available at http://www.aflatoxinpartnership.org/uploads/PACA%20Stunting%20Policy%20Brief.pdf)

availability of nutritious foods.[146] Potentially contaminated foods that do not meet safety standards may be sold locally in informal markets, exposing poorer consumers to health risks[147].

9.4 Public health risks, AMR, transboundary and zoonotic diseases

Increasing impacts of zoonotic diseases on human health. The world and its socio-economic development faces a staggering burden of both old and new human, zoonotic and endemic livestock diseases which threaten household food security and nutrition particularly in poor and vulnerable communities. Increased movement of people, terrestrial and aquatic animals, plants and products in the globalized economy on the one hand, and the concentration and intensification of production systems on the other, have accelerated and enlarged the threat of zoonotic diseases, i.e. infectious diseases of animals that can naturally be transmitted to animals. This has large repercussions on human health, as more than 70 percent of the infectious diseases that emerged in humans since the 1940s could be traced back to animals, including and those which come from wildlife (Jones et al., 2008)[148]. Among these we can mention Severe Acute Respiratory Syndrome and associated corona viruses in bats, civet cats, and other mammals; Henipaviruses in swine, bats and horses; Ebola virus in wildlife; and, rabies virus and associated viruses (Bennet, 2006; Calisher et al., 2006; FAO, 2013; Jones et al., 2008; Turmelle and Olival, 2009)[149]. The rapid spread of the H5N1 avian influenza (HPAI) virus in Southeast Asia in 2004 and then into Europe and Africa in 2005, was accompanied by the fear that a human influenza pandemic might emerge from domestic poultry. More than 60 countries were affected by virus incursions, over 300 million poultry died or were destroyed, and millions of farmers and producers suffered losses running into billions of dollars, for instance USD3.3 billion in USA (Green, 2015); USD 2.9 billion in Egypt[150]. H1N1 Influenza spread worldwide in 2009. Vector-borne zoonotic diseases such as Rift Valley Fever continue to affect parts of Africa, threatening to spread to the Middle East, the Gulf countries and southern Europe. Trypanosomosis and East Coast Fever are among the most devastating diseases in sub-Saharan

[146]Roesel, K. and Grace, D., 2015. *Food safety and informal markets- animal products in sub-Saharan Africa*. London, UK: Routledge

[147]For more information see: Comments On The Committee on Food Security Recommendations On Connecting Smallholders To Markets prepared on behalf of the Research Committee on Sociology of Agriculture and Food (RC40) of the International Sociological Association (ISA). (available athttp://www.fao.org/fileadmin/templates/cfs/Docs1516/OEWG_Small/Written_Inputs/CFS_Smallholders_Inputs_Zero_Draft_RC40.pdf)

[148] Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A. Balk, D., Gittleman, J.L., Daszak, P. (2008). Global trends in emerging infectious diseases. Nature, 451(7181): 990-993

[149] Bennet, M. (2006). Bats and human emerging diseases. Epidemio. and Infect., 134(5): 905-907.
Calisher, C. H., Childs, J.E., Field, H.E., Holmes, K.V., Schountz, T. (2006). Bats: important reservoir hosts of emerging viruses. Clinical Microbiology Reviews, 19(3): 531-545.
FAO (2013). World of Livestock 2013: Changing Disease Landscapes. FAO, Rome, 111pp (available at http://www.fao.org/3/contents/f31c631b-082e-573c-8744-570c5105106e/i3440e00.htm).
Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A. Balk, D., Gittleman, J.L., Daszak, P. (2008). Global trends in emerging infectious diseases. Nature, 451(7181): 990-993.
Turmelle, A.S., Olival, K.J. (2009). Correlates of viral richness in bats (order Chiroptera). EcoHealth, 6(4): 522-539.

[150] Green, J.L. (2015). Update on the Highly-Pathogenic Avian Influenza Outbreak of 2014-2015. Congressional Research Service, July 20, 2015 (https://www.google.it/?gws_rd=ssl#q=Green+Update+on+the+Highly+Pathogenic+Avian+Influenza+Outbreak+2015).
Experts consultation, 2006 http://www.kuna.net.kw/ArticlePrintPage.aspx?id=1648770&language=en.

Africa. The Ebola outbreaks in 2014 in several African countries with serious consequences for affected countries showed again the devastating impact of zoonotic diseases.

Middle East Respiratory Syndrome (MERS) CoV is a further confirmation of this worrisome trends of pathogen global spread captured by the international press. Since MERS-CoV first emerged in 2012 in the Middle East, it has spread over 20 countries on four continents, affecting mainly camel handlers and healthcare workers, with about 30-40 percent mortality in MERS-CoV infected humans (Zaki *et al*., 2012; de Groot *et al*., 2013)[151]. Although the old endemic diseases of brucellosis, tuberculosis and rabies, together with vector-borne diseases, such as tsetse-transmitted trypanosomosis and tick-borne diseases do not get such headlines, they remain serious threats for animal and human health. Their impact is considerable to the whole livestock agricultural and socio-economic development. Losses due to tsetse-transmitted trypanosomosis in sub-Saharan Africa are evaluated between USD 6 and 12 billion per year in the cattle industry alone (Hursey and Slingenbergh, 1995) and up to 10 percent of agricultural GDP in ten fully tsetse infested countries (Mattioli *et al*., 2004); losses due to ticks and tick-borne diseases are estimated in the range of 18 billion USD worldwide (de Castro, 1997)

Climate change increases the risk of zoonotic diseases. In addition, climate change, environmental conditions and land pressure are drivers susceptible to modify not only animal production and productivity but also the disease dynamics at the human-animal-ecosystem interface, and the worldwide redistribution of vectors, pathogens and infected hosts setting off novel epidemiological patterns and spread of many endemic diseases, such as bluetongue and West Nile viruses, also into new territories (Kilpatrick and Randolph, 2012; de La Rocque *et al*., 2011)[152].

Increasing antimicrobial resistance further burdens human health. The burden of zoonotic diseases on human health not only is magnified by the ongoing climate change, but also by increasing antimicrobial resistance. Antimicrobial resistance (AMR) is a major global public, animal health and agricultural issue of increasing concern with the potential to reverse gains of modern medicine throughout the 20th century. Antimicrobials are still heavily used not only to preserve human and animal health but also in the broader context of the livestock and agricultural industry. The Review on Antimicrobial Resistance (O'Neill, 2016), commissioned by the British Prime Minister, estimates that, if no action is taken today, by 2050, 10 million lives a year and 100 trillion USD of economic output are at risk from drug-resistant infections. Today, approximately 700,000 people die of drug-resistant infections every year. The Low and Middle Income Countries (LMICs) face the greatest burden of rising drug-resistant infections particularly in addressing AMR. Consumption of antibiotics is predicted to increase in LMICs.

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[151] *Zaki, A.M., van Boheemen, S., Bestebroer, T.M., Osterhaus, A.D.M.E., Fouchier, R.A.M. (2012). Isolation of a novel coronavirus from a man with pneumonia in Saudi Arabia. New England Journal of Medicine, 367 (19): 1814–20.*

de Groot R.J.; Baker, S.C., Baric, S.R., Brown, C.S., Drosten C., Enjuanes, L., Fouchier, R.A.M., Galiano, M., Gorbnalenya, A.E., Memish, Z.A., Perlman, S., Poon, L.L.M., Snijeder, E.J., Stephens, G.M., Woo, P.C.Y., Zaki, A.M., Zambon, M., Ziebuhr, J. (2013). "Middle East Respiratory Syndrome Coronavirus (MERS-CoV): Announcement of the Coronavirus Study Group". Journal of Virology, 87(14): 7790–7792.

[152] Kilpatrick, A.M., Randolph, S.E. (2012). Drivers, dynamics, and control of emerging vector-borne zoonotic diseases. Lancet, 380(9857) 1946-1955.

de La Rocque, S., Balenghien, T., Halos, L., Dietze, K., Claes, F., Ferrari, G., Guberti, V., Slingenbergh, J. (2011). A review of ternds in the distribution of vector-borne diseases: is international trade contributing to their spread? Rev. Sci. Tech., 30(1): 119-130.

Multi-disciplinary approach of zoonotic diseases, climate change and AMR is ongoing. Considering the equation disease – production systems – climate – environment – human health, and the related interaction dynamics of diseases, effective management requires comprehensive and integrated interventions to cope with the complexity of the problem and to reduce the potentially detrimental consequences on animal health, production and productivity and human population. Enhancing international and regional cooperation and coordination is crucial to prevent the disease at the source. In this context, the One Health multidisciplinary and cross sectoral approach (FAO, 2011)[153] is surely the best strategy to promote and integrate immediate and long term disease intervention strategies.

In addition, to address the issue of AMR in an holistic way, the world has come together to develop a Global Action Plan (agreed by all 194 members of the World Health Organization - WHO) with clear responsibility in the food and agriculture sector, which reflects aspects of food safety, terrestrial and aquatic animal production and health, crop production, water and soil management, and agriculture and commercial regulatory frameworks.

FAO works closely with WHO and the World Organization for Animal Health OIE) on advising countries, the medical community and agricultural producers on the appropriate use of antimicrobials and guidance to minimize the threat of AMR.

[153] FAO (2011). ONE HEALTH: Strategic Action Plan http://www.fao.org/docrep/014/al868e/al868e00.pdf

10 Structural change and employment

The development, of countries may imply a process of change that transforms the production structure of their economies.

The structural change of economies can be measured by changes in the relative importance of sectors, the related reallocation of factors across sectors as well as changes in their productivity. Increased specialization of labour may also occur together with a diversification of production sectors. In addition if structural changes on the production side are associated with income changes, modifications of the consumption basket may also occur, such as shifts in dietary patterns, in the consumption of manufactured goods as well as in the demand of welfare-related services, such as housing, education, health, security etc.

Empirical observations show that high-income countries, which originally relied on primary sectors, especially agriculture, progressively shifted their economic systems towards industry and service sectors. During this process, labor was reallocated among sectors while productivity of input factors increased in each sector and productivity differences among sectors declined.

In low and middle income countries, income growth over the past decades was characterized by increases in output that came along with mobility of labour across economic sectors and geographic territories within and across countries. Structural changes have been taking place at varying degrees and levels across all countries and regions; they have been a cause as well as effect of income growth.

Demographic trends, such as changes in fertility rates, population growth and an increasing proportion of youth entering the labor force in certain regions, ageing of societies in others, and urbanization almost everywhere, influenced the paths of structural changes in diverse ways. A range of policies and institutional changes during the 1980s and 1990s, further influenced the process, through infrastructure projects and trade liberalization.

Currently, while transformation processes keep going, sustainability concerns emerge regarding the use of the scarcer natural resources in agriculture and other sectors.

10.1 Rural transformation and agri-business development

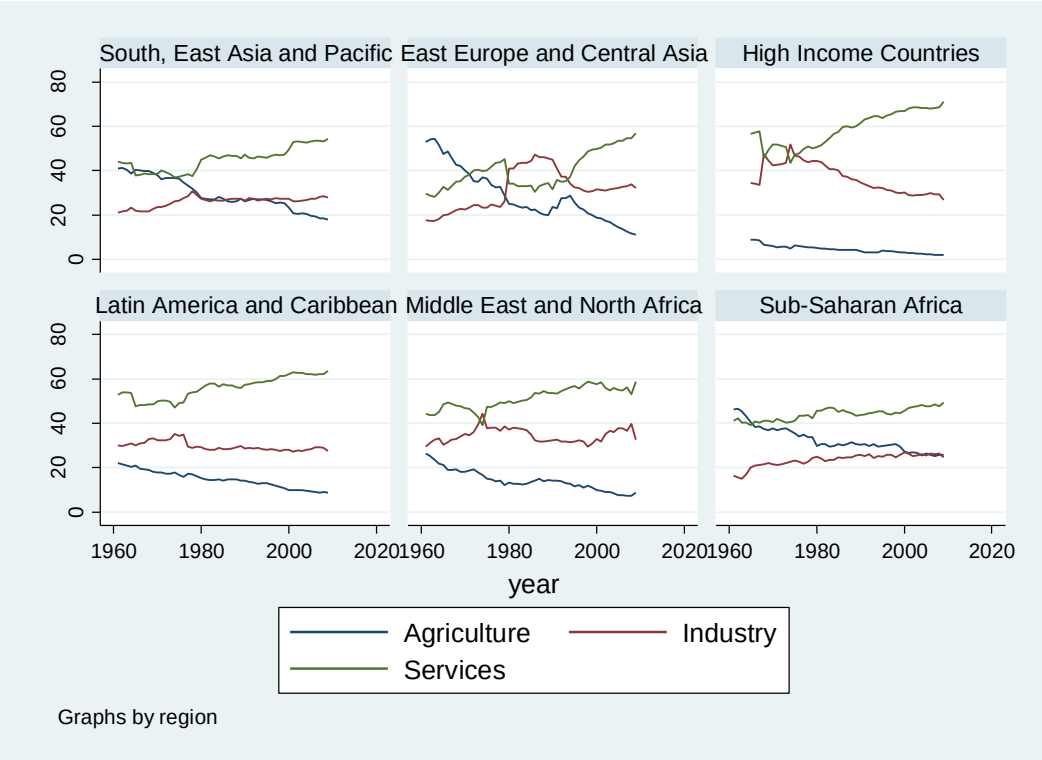
The conventional paradigm of structural transformation and agricultural and food systems transition is that structural changes are taking place together with the transition of the agricultural sector, which becomes more capital intensive and more integrated to markets. Smallholders and members of family farmers diversify their income and employment sources and often quit the sector. The mobility which many call exit from agriculture, for the most part takes place across generations (rather than changing activities within a lifetime), and has implications in terms of output composition and productivity in agriculture and the other sectors.

Despite different patterns across countries and regions, some forms of structural transformation, measured by the relative contributions to GDP shares of employment of different sectors, are observable. They have led, in the last fifty years, to reductions of the share of agriculture value added in GDP (Figure 10.1), and, in the last twenty years, to slightly declining shares of employment (Figure 10.2).

Continuing population increases, urbanization trends and sustainability concerns are expected to adapt and modify the conventional paradigm of structural and rural transformation and agricultural and food systems transition. The adjusted paradigm needs to accommodate challenges emanating from such trends together with changes in preferences and inequalities in the distribution of resources. The importance of agriculture and related businesses, in national economies and people's livelihoods, may increase in many instances.

The transition of the sector and the transformation of the economy also coincided with the rise of rural towns and small urban centers contributing to the transformation and economic and social development of rural areas. Agricultural transition and rural transformations have been reinforced through supply and demand interlinkages with urban areas and contribute to the reduction of poverty and the gaps observed with urban areas in welfare indicators including in health, social and other livelihood aspects.

Figure 10.1: Sectoral contribution of value added in GDP (percent by region)



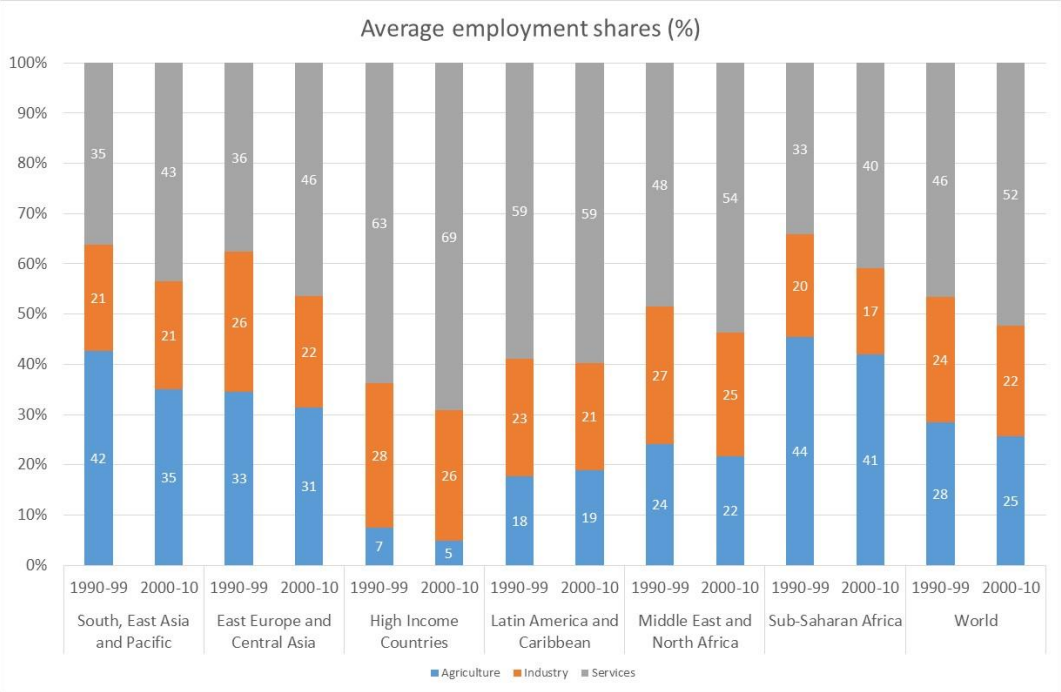
Source: Own calculations (data from the World Development Indicators, World Bank)

Farmers who stayed in the sector changed the crop mix shifting from multi to single cropping while they also moved from staples to higher value food and cash crops. Previously pervasive risks have been better managed, impacts of shocks have been insured while markets substitute for commodities previously produced on their farms. Gradually, farms became profitable business and farmers were empowered to integrate into commercialized food systems, received higher incomes and worked with better technologies[154].

[154] Binswanger–Mkhize, Hans P. (2012). "India 1960-2010: Structural Change, the Rural Nonfarm Sector, and the Prospects for Agriculture", Seminar Paper presented at University of California at Berkeley, World Bank. 2009. Awakening Africa's Sleeping Giant: Prospects for Commercial Agriculture in the Guinea Savannah Zone and Beyond. Directions in Development; agriculture and rural development. World Bank

The conventional paradigm of transition implies that consolidation of land holdings occur at the tail end of the land distribution to gain economies of scale. This conventional paradigm however, is not observed in many parts of Africa and South Asia, where land consolidation does not occur and even, occasionally a declining average farm size and further fragmentation of landholdings occurs. In other cases, labor mobility and youth's unwillingness to stay in the sector, result in the increase of the average age of farmers and stagnant or lower yields and productivity. In many cases and irrespective of the type of sectoral transition, unequal distribution of resources and especially capital may result in less efficient outcomes and occasionally in social tensions[155].

Figure 10.2: Sectoral employment shares (percent by region)



Source: Own calculations (data from the World Development Indicators, World Bank)

Population, income growth and urbanization signified quantitative and qualitative changes in the demand for food that led to the development of agro-industrial production and market chains. The development of these chains has quantitative and qualitative implications in the demand for food products including the allocation and use of natural resources, input factors and labor for their production[156].

[155] To some degree the so called "Arab Spring" refers to these such issues. See Fox. L, A. Thomas and C. Haines, (2015), Structural transformation and productivity, What Africa can hope for? mimeo, presented at CSAE conference 2016 and Acemoglu, D, T A Hassan, and A Tahoun (2014), "The power of the street: evidence from Egypt's Arab Spring", NBER Working Paper w20665. Any evidence or references of this "counter evidence"?

[156] FAO & UNIDO. 2009. Agro-industries for development. da Silva C. A. et al. (Eds). Wallingford: Food and Agriculture Organization of the United Nations and the United Nations Industrial Development Organization. Available at: http://www.fao.org/docrep/017/i3125e/i3125e00.pdf

Small-to-medium enterprises account for a large and growing share of the agricultural sector's value-addition and employment[157]. Due to the informal nature of agro-industries in most countries, there is scarce evidence on the exact number of jobs created in the sector. However, some evidence exists of high and increasing levels of females employed in pack houses of high value chains[158].

On the other hand, there is the emergence of agribusiness firms, which increasingly concentrate parts of the manufacturing, distribution and retail while also influencing demand and eventually dietary patterns. Vertical integration occurs at national and across countries levels with the development of global value chains. The development of agri-business irrespective of their size, influence the distribution of rents, market functioning, formalization of production and market activities, production diversification and differentiation[159].

Agro-industries make important contributions to employment and income generation in low and middle-income countries. Off-farm activities such as handling, packaging, processing, transporting and marketing of food and agricultural products provide multiple opportunities for employment. By increasing demand for raw agricultural commodities, agro-industries contribute to increases in farmer incomes[160].

The value of agro-industries as a share of total manufacturing is significant in many Sub-Saharan African countries contributing almost up to 60% in selected countries[161]. However, this sector provides little contributions to exports.

[157] FAO & UNIDO. 2009. Agro-industries for development. da Silva C. A. et al. (Eds). Wallingford: Food and Agriculture Organization of the United Nations and the United Nations Industrial Development Organization. Available at: http://www.fao.org/docrep/017/i3125e/i3125e00.pdf

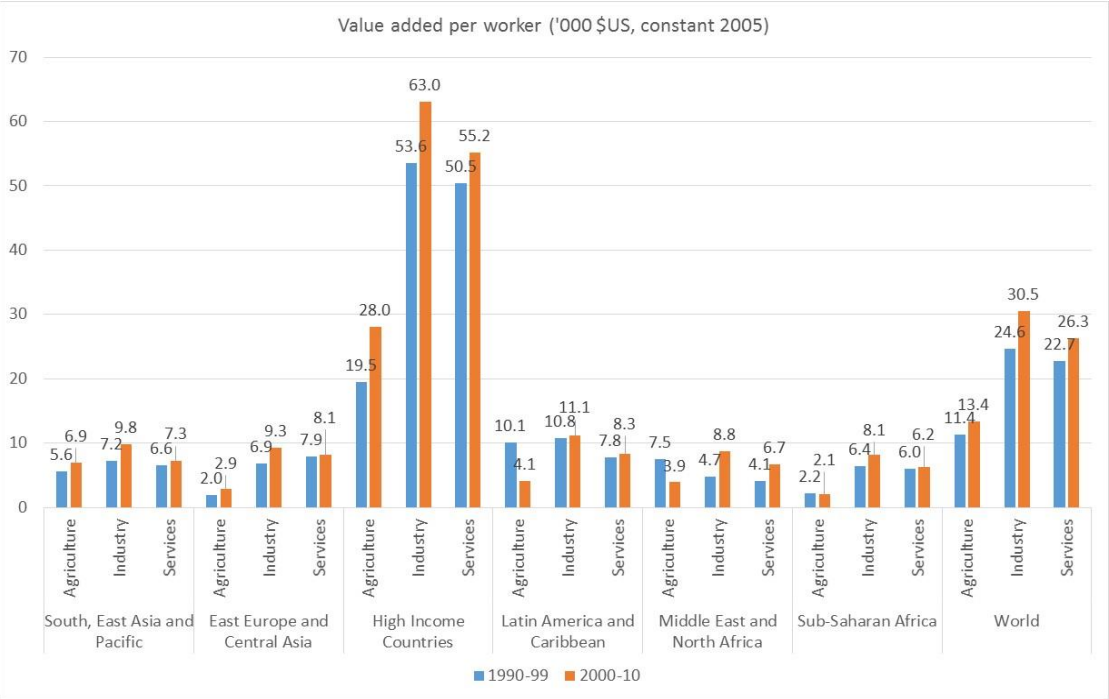
[158] Wilkinson and Rocha in FAO & UNIDO. 2009. Agro-industries for development. da Silva C. A. et al. (Eds). Wallingford: Food and Agriculture Organization of the United Nations and the United Nations Industrial Development Organization. Available at: http://www.fao.org/docrep/017/i3125e/i3125e00.pdf

[159] FAO & UNIDO. 2009. Agro-industries for development. da Silva C. A. et al. (Eds). Wallingford: Food and Agriculture Organization of the United Nations and the United Nations Industrial Development Organization. Available at: http://www.fao.org/docrep/017/i3125e/i3125e00.pdf

[160] FAO & UNIDO. 2009. Agro-industries for development. da Silva C. A. et al. (Eds). Wallingford: Food and Agriculture Organization of the United Nations and the United Nations Industrial Development Organization. Available at: http://www.fao.org/docrep/017/i3125e/i3125e00.pdf

[161] Roepstorff, T. M., Wiggins, S. & A. M. Hawkins (2011). The Profile of Agribusiness in Africa. In Yumkella, K. K., Kormawa, P. M., Roepstorff, T. M. & A. M. Hawkins (2011) Agribusiness for Prosperity, UNIDO.

Figure 10.3: Sectoral value added per worker ('000 $US by region)



Source: Own calculations (data from the World Development Indicators, World Bank)Note: The data exclude Argentina.

Agro-industrial strategies are often included in broader strategies such as agricultural strategies, industrial strategies, export or investment promotion strategies. However, the broad nature of such strategies can lead to unclear and incomplete action plans for defining and achieving agro-industrial objectives. Thus, economies may miss opportunities to improve agricultural and food systems[162]. Recent trends are stimulating a growth in the demand for high-value commodities, processed products and ready prepared food, provide compelling reasons for developing countries to focus on agro-industry development[163].

Structural transformation, the transition of the agricultural sector (trends in farm sizes, labour productivity, capital intensity etc.) and outcome in terms of changes in welfare, are country and region-specific. They depend on initial conditions, demographic trends (population growth, urbanization, youth bulges and/or ageing, migration), geography, natural resource constraints and increased competition for water, land and forests, environmental threats, agricultural labour constraints (shortages in some areas, surpluses elsewhere), changing dietary patterns and

[162] FAO. 2011. Appropriate food-packaging solutions for developing countries. Rome: Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/docrep/015/mb061e/mb061e00.pdf and FAO. 2011 and Innovative policies and institutions to support agro-industries. da Silva, C. A. and Mhlanga, N. (Eds.). Rome: Food and Agriculture Organization of the United Nations. Available at: www.fao.org/docrep/015/i2420e/i2420e.pdf

[163] Byerlee, D., A. Garcia, Å. Giertz, and V. Palmade .2013. Growing Africa: Unlocking the Potential of Agribusiness. World Bank. http://siteresources.worldbank.org/INTAFRICA/Resources/africa-agribusiness-report-2013.pdf .

policies and strategies. Region-wide comparative evidence and studies, highlight the following[164]:

Asia: the so-called "Green Revolution" in Asia contributed to increasing productivity and profits of small farms, which became commercial and profitable but also smaller because of population growth. Most countries in the region have gone through accelerated transformation processes, yet there are marked differences in speed and the nature of agricultural change, depending on constraints emanation from geography, natural resources, social factors, land scarcity and policies. In China, for instance, which experienced one of the highest rates in industrialization and overall productivity growth the last decades, the productivity in agriculture increased threefold since the 1980s. In the overall region (South-East Asia and pacific) in the last decade, the labour productivity, in terms of value added per worker, increased by 23% (figure 3).

Latin America. Agricultural income growth in recent decades has been associated with incentive changes due to policy reforms, and subsequent shifts in technology, and the composition of production and the farm size distribution. In most cases, these changes have led to a simultaneous growth in farm sector incomes, the shedding of agricultural labour and expansion of urban, non-agricultural employment. In Brazil, for instance, policies that supported larger farms contributed in creating a highly commercialized agricultural sector and labor productivity in agriculture increased more than four times in the same period[165]. Nevertheless the evidence indicates heterogeneous transformation paths as in some countries the number and proportion of employment in agriculture appear increasing with higher speed than the sectoral output, resulting in declining labour productivity in the sector (figure 3)[166].

Sub-Saharan Africa. In Africa, recent empirical work indicates that, even though better institutions, increased international trade and better economic policies may have significantly contributed to the high economic growth rates witnessed the last decade[167], the structural transformation is not accommodating productivity increases in agriculture, which is in fact declining, both in absolute terms and relative to industry and services (Figure 3). As the region's population is expected to more than double over the next 35 years, more than 10 million new labour market entrants may seek for remunerative employment every year. Unfortunately, the current size of higher productivity non-agricultural sectors is small and even if it expanded at a very fast pace over the coming decades, they would be able to absorb only a limited share of the new workers. Therefore, the agricultural sector will need to provide additional income opportunities for a still increasing rural labour force, by better exploiting its potential. For instance, production and export data signal that African countries accounted for 66 percent of cocoa bean production between 1993 and 2013. However, none of the African countries made

[164] Outcomes from FAO Conference on Rural transformation, agricultural and food system transition: Building the evidence base for policies that promote sustainable development, food and nutrition security and poverty reduction held the 19-20 September 2016, FAO headquarters, Rome, Italy.

[165] COAG 2010, POLICIES AND INSTITUTIONS TO SUPPORT SMALLHOLDER AGRICULTURE, FAO and Calculations based on WDI for the period from 1980 to 2010.

[166] Reductions in agricultural labor productivity in Latin America and the Caribbean, strongly emerge in Colombia, Ecuador, Guatemala, Jamaica, Paraguay, Peru, Saint Lucia, Suriname and Uruguay. However those that mostly influence the regional average are in Colombia, Ecuador, Paraguay and Peru. The trend requires further analysis at country level but data problems cannot be excluded.

[167] Zedillo, E, O Cattaneo, H Wheeler (eds.) (2015), Africa at a Fork in the Road: Taking Off or Disappointment Once Again? New Haven, CT: Yale Center for the Study of Globalization.

it to the top 10 countries exporting chocolates. The World Bank estimates that food production and processing in Africa could generate US$ 1 trillion per year by 2030[168].

Middle-East and Northern Africa. The dominance of the high productivity and low employment mineral resource sectors in most MENA countries has affected productivity growth in other sectors, including in agriculture. This has slowed more benign economic diversification and perpetuating high dependence on food imports.

The peculiar role of urbanization in reshaping the rural space. Particularly in the poorest regions of the world, Sub-Saharan Africa and South Asia, changes in food systems due to urbanization are reshaping agriculture. As the food demand is rapidly urbanizing and shifting towards fruits, vegetables and meat, and food supplies are mostly sourced by domestic markets, new opportunities may arise for agricultural income diversification.

The needs to serve large urban markets command improved storage and transportation and food processing capacity and, in some parts, is leading to land consolidation and increased importance of mid-sized farms in food production. Where infrastructure, credits and other related facilities are missing or slow to develop, many farmers and rural populations can fail to benefit from this new dynamics. Where rural townships and intermediate cities are better developed, more agricultural ad non-agricultural jobs creation and poverty reduction tends to take place[169] . Rural transformations in these contexts are being shaped by the interaction of "two middles" in rural areas: 1) The "hidden middle" of rural societies: This refers to the emergence of rural towns which provide the most dynamic ground for economic and social activities to take place through high demand for goods, services and food; 2) The "middle segment" of the food system: The component of the system after primary production that refers to trading, processing, packaging, distributing and storing agricultural commodities including food, until before final consumption.

While smallholder agriculture continues to dominate most of the rural geography, productivity increases and poverty reduction will strongly depend on how they can link to the rest of the system, gain from the economic diversification taking place, and overcome the constraints they face in accessing resources and technology, and markets. Further, social protection policies and safety nets will have an important role to play in smoothing the sometimes painful transition pathways for vulnerable smallholders to shift to higher productivity and more diversified agriculture and/or by moving to other sectors of the economy.

10.2 Employment challenges, especially for youth

Although the current generations already in or entering the labor force in low and middle-income countries are more educated than the previous ones, their employment and earnings prospects are considered as weak and sometimes worse than those of their parents. Youth populations in urban areas have been expressing their discontent lately concerning the lack of available labor opportunities and especially poor expectations (e.g. the Arab spring). Moreover,

[168] Byerlee, D., A. Garcia, Å. Giertz, and V. Palmade .2013. Growing Africa: Unlocking the Potential of Agribusiness. World Bank. http://siteresources.worldbank.org/INTAFRICA/Resources/africa-agribusiness-report-2013.pdf

[169] Christiaensen, Luc & Todo, Yasuyuki, 2013. "Poverty reduction during the rural-urban transformation: the role of the missing middle," Policy Research Working Paper Series 6445, The World Bank and Dorosh, P. and J. Thurlow (2014), Can cities drive African development? Economy wide analysis for Ethiopa and Uganda, World Development, 63, 113-123

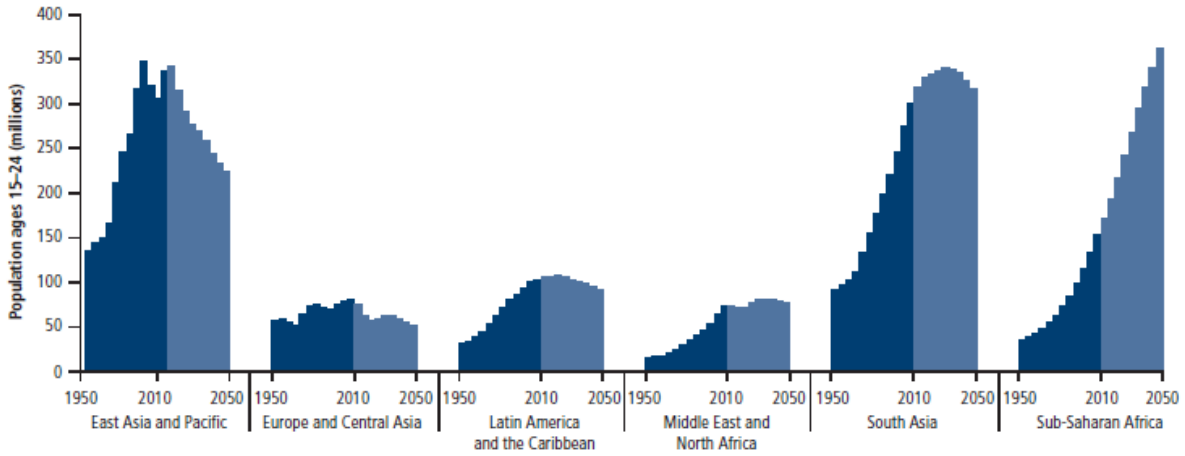
the majority of people, especially young, who are living in rural areas are also facing rather worse prospects for stable and remunerative employment opportunities, being also less educated relative to their urban counterparts[170].

Young today (i.e. those aged between 10 and 24 years) are more than ever before in human history; in some low and middle-income countries one third of their population is of this age[171].

The youth in low and-middle income countries, represents an opportunity for growth and development, especially when considering the ageing populations and low fertility rates in high-income countries. Most of youth is concentrated in Africa and South Asia and the two regions will continue to house them in the years to come (Figure 10.4). In the near future, the average age gap with the rest of the world is expected to increase between these two regions and the rest of the world. Evidence shows that if fertility rates continue to decline in Africa, the number of working age adults relative to dependents will increase from 1 in 1985 to 1.7 in 2050.

Especially for youth, building the necessary human capital through effective basic and secondary education may contribute to shape their employment opportunities. Even though today the average young Zambian or Ghanaian has more schooling than the average Italian or French had in 1960, deficiencies in educational quality limit the impact on productivity below its potential. This because going to school in several cases is not associated with actual skill building, education and learning, due to substantial failures in delivery of educational services including absenteeism, poor teachers' preparation and teaching quality. Improving learning in primary and secondary schools is necessary to prepare a solid foundation for youth in the job market[172].

Figure 10.4. Estimates and projections of the number of 15 to 24 year-olds



Source: United Nations 2011.Note: Each bar shows an estimate or a projection of the number of 15- to 24-year-olds for one year at five-year intervals.

The potential for employment opportunities differs across countries. Employment challenges are pressing for countries whose economy depends heavily on mineral and mining sectors.

[170] World Bank. 2014. Youth Employment in Sub-Saharan Africa. Washington, D.C

[171] World Bank. 2014. Youth Employment in Sub-Saharan Africa. Washington, D.C and UNFPA, 2014. The Power of 1 Billion: Adolescents, Youth and the Transformation of the Future

[172] World Bank. 2014. Youth Employment in Sub-Saharan Africa. Washington, D.C and Fox, Louise, Alun Thomas, Cleary Haines, and Jorge Huerta Munoz. 2013. "Africa's Got Work to Do: Employment Prospects in the New Century." IMF Working Paper 13–201, International Monetary Fund, Washington, DC.

Public policies in these countries will be necessary to support the development of other sectors (i.e. agriculture, manufacturing, services and industry) in order to absorb available labor through the diversification of economic activities and increasing tradability of services.

The options for wage earning jobs in industry are also diverse by regions. For instance, in Africa, wage earning employment opportunities are expected to increase by 55 percent in the industrial sector (excluding manufacturing and household enterprises) in the next 10 years, but this represents an increase from 3 to 4.5 percent in terms of overall employment.

Across different countries in South Asia, opportunities are also diverse but services in India appear quite dynamic and basic industries in other countries, despite the fact that agriculture still is the major employer. Off farm small scale household business are able to provide productive and remunerative employment opportunities as long as constraints arising from informality and low human and physical capital are addressed.

For agriculture and off farm household enterprises in rural and urban areas to create and sustain employment opportunities for the youth, four major paths can be considered, referring to (i) full time work on own family farms, (ii) part time on farm work and off farm household enterprise, (iii) agricultural wage work and (iv) full time off farm household enterprise.

The Increasing demand of agricultural products may provide opportunities for employment. High food prices may contribute to increasing productivity but they also contribute to higher real wage costs and low competitiveness[173]. Addressing structural constraints remains the key priority for agriculture's capacity to create decent employment opportunities[174]. Nevertheless, social protection schemes and safety nets will also be necessary to support skills building of youth entering the labor force or labor mobility across sectors and geographic regions.

For the most part, smallholder farmers are still caught in what can be considered a trap of low earnings, low savings and investments and therefore low production and productivity. Small farm sizes, low access to equipment and inputs reduce opportunities from market integration and economies of scale. Poor rural infrastructure in terms of transport, access to electricity and irrigation, perpetuate the impacts of the trap.

Beyond agriculture, most of the population working outside the sector in low and middle income countries are involved in informal household enterprises both in urban and rural areas. This is frequently part of a diversified family strategy, together with agriculture in rural areas or wage earning activities in cities. For example, between 30 to 50 percent of rural households are involved in a non-farm household enterprise. However, the productivity of non-farm household enterprises is low, but often earnings per person are higher than in agriculture or in wage employment in urban areas. Small individual businesses are often involved in retail trade of food and grocery items. In cities they are often mobile and substitute for convenience stores, supermarkets and shopping malls. They are also often involved contribute in the transformation of goods and natural resources (e.g. processing grain, charcoal, bricks etc.) or are engaged in

[173] World Bank. 2014. Youth Employment in Sub-Saharan Africa. Washington, D.C

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

artisanal activities and construction. They remain small and without capital even after years of operation, which indicates limited development potential. In national income distributions, they concentrate in middle quantiles.

Governments and policies usually ignore (or even harass) them, even though occasionally efforts are undertaken towards their formalization and conversion to small and medium enterprises. The potential for employment creation is significant especially in urban areas as long as productivity and size considerations are accounted for[175].

Besides opportunities provided by agriculture and off farm household enterprises, wage-earning jobs are expected to represent an important option for job creation. Small and medium size enterprises evolving from existing household enterprises may have the possibility to capture economies of scale, thus improving the efficiency of the manufacturing sector, while secondary school graduates aspire to work in these type of jobs. However, even if this sector is generating jobs at a fast pace, the very low initial base in most low and middle income countries, especially in Africa, implies that it is difficult for the sector to absorb the millions of people expected to enter the labor force every year. As a complementary opportunity for jobs' creation, the potential for employment generation in export-oriented firms (in industries or services) could also be considered as long as the proper institutions and proper governance mechanisms for benefitting from this type of industrialization are put in place.

For these paths to result in job increases, institutional and governance mechanisms need to be created that facilitate the provision of essential services and improve the know-how and skills-base. For instance, risky environments and poor collateral limit access to credit and financial capital for farmers in rural areas and off farm household enterprises everywhere. There is though, a range of novel institutions and instruments that are promising and have the potential to reduce constraints to financial access. These include formal and informal group saving and loan associations, different forms of collateral (i.e. chattel mortgages) and leasing, service bundles (e.g. contract farming), that incorporate credit, inputs and training and mentoring for youth.

In addition, training can support a path for youth employment in non-farm household enterprises. Technical training (e.g. apprenticeships), building of business or behavioral skills or a mix of the above are shown to be effective as long as they are carefully planned.

Also the incorporation of household enterprises in planning processes has the potential to support income generation and employment opportunities as long as care is given for the provision of support services (e.g. security, sanitation, electricity and transport). Owners of these small enterprises are willing to pay for such services through fees and taxes, even though at times they pay for them in higher rates than larger businesses[176].

In terms of land rights and policies for farm activities, lack of clarity in policies and insecurity in tenure, limit own investments in land improvements and hence output and productivity. Inventories of land and registration need to be promoted along with land titles so that market constraints are addressed. On the other hand, large commercial landholdings in agriculture are socially contentious, often not transparent and the evidence shows poor results both in terms of employment creation and in terms of generation of revenues for the state.

[175] World Bank. 2014. Youth Employment in Sub-Saharan Africa. Washington, D.C,
[176] World Bank. 2014. Youth Employment in Sub-Saharan Africa. Washington, D.C

Investments in infrastructure may have positive returns for development and poverty reduction and may contribute to employment creation both in and out of agriculture.. Nonetheless, assessments are necessary in order to prioritize and select projects

Finally, the business climate is far from enabling, with high costs of intermediation, bureaucracy, red tape and corruption. Evidence shows for instance that Africa is not a cost-friendly location for business. For each unit of sales, African firms spend about 20 percent more in direct (labor, capital, electricity), indirect (transport, other energy, telecommunications, regulatory environment) and invisible (corruption, security, red tape, electricity interruptions etc.) costs than firms in other [177]regions.

10.3 Migration trends

To escape food and nutrition insecurity, extreme poverty and related uncertainties people increasingly migrate for distress and/or in search of better opportunities[178]. In 2015, there were 244 million international migrants, including 150 million migrant workers[179]. The number of international migrants has increased by 71 million compared to 2000, over 40 per cent more.

Nearly two thirds of all international migrants live in Europe (76 million) or Asia (75 million). Northern America hosts the third largest number of international migrants (54 million), followed by Africa (21 million), Latin America and the Caribbean (9 million) and Oceania (8 million). International migrants expected to reach 405 million by 2050[180].

The phenomenon of internal migration is even larger in scale. The most recent estimates account for 740 million internal migrants in 2013, compared to 763 in 2005 (as reported in Table 10.1)[181].

International migrants, including refugees, as a share of global population increased from 2.9 in 2005 to 3.3 percent in 2013 (that is, from 190 million to 232 millions).

Out of the 232 million international immigrants in 2013, 150 million (4.5 percent of the global labour force the same year) were employed.

[177] Iarossi, G. (2009),Benchmarking Africa's Costs and Competitiveness; The Africa Competitiveness Report, eds. J. Blanke (World Economic Forum, Geneva)

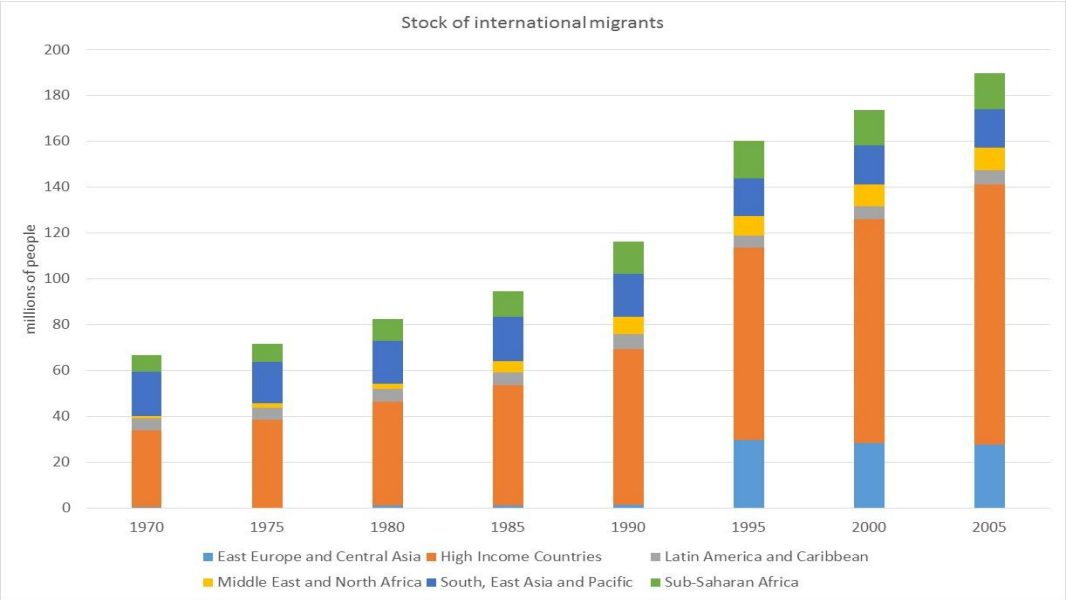
[178] Legally, the definition of migration is not unambiguous. The term migration is often used interchangeably with refugees, economic migrants and those fleeing violence. Importantly, the status of a migrant is not defined and hence not recognized by international law; it is mainly used to describe people seeking work opportunities and with States having no legal obligations to migrants (Goldenzeil, 2015).

[179] UNDESA 2015. Trend in International migration 2015. Population Facts. December 2015, no. 2015/4.
ILO. 2015. Global estimates on migrant workers. Results and methodology. Special focus on migrant domestic workers.

[180] Source needed

[181] This paragraph builds upon the FAO position Paper on Migration. Zero Draft 24-06-2016. FAO

Figure 10.5: International migrants, 1970-2005 (million people)



Source: FAO calculations (data from the World Development Indicators, World Bank)

Table 10.1: Estimated number of lifetime internal migrants in 2005

	Millions	Percent
Africa	113.5	14.9
Asia	282.1	37
Latin America & Caribbean	100.2	13.1
Europe	166	21.8
North America	91.5	12
Oceania	9.3	1.2
World	762.6	100

Source: UN Population Division (2013)

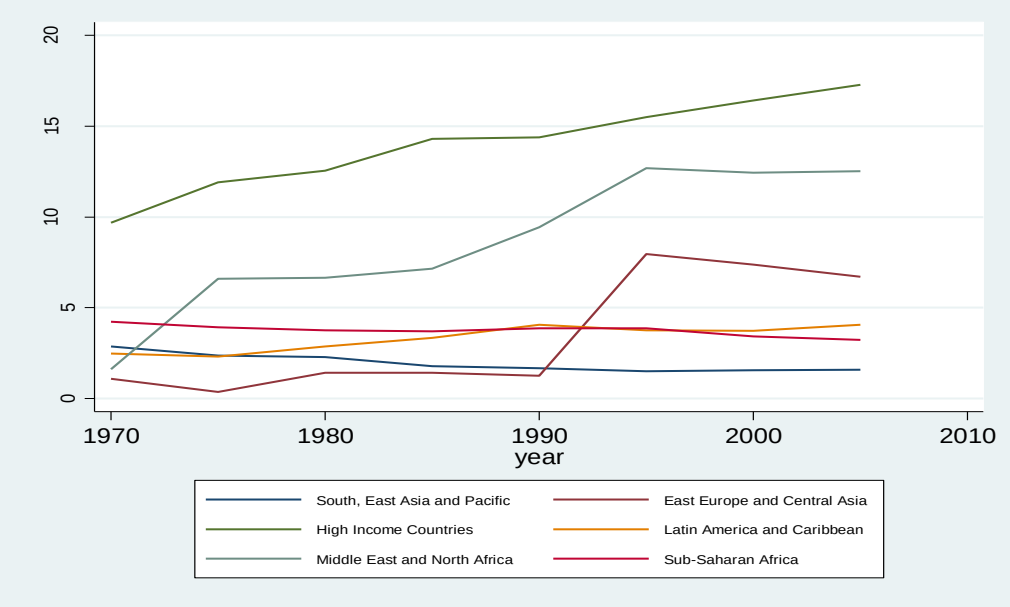
In many parts of the world, migration occurs primarily between countries that are located within the same major area. In 2015, the majority of the international migrants living in Africa (87 per cent), Asia (82 per cent), Latin America and the Caribbean (66 per cent) and Europe (53 per cent) originated from another country located in the same major area. In contrast, the majority of international migrants living in Northern America (98 per cent) and Oceania (87 per cent) were born in a major area other than the one where they currently reside. Germany and the Russian Federation host the second and third largest numbers of migrants worldwide (12 million each), followed by Saudi Arabia (10 million), the United Kingdom of Great Britain and Northern Ireland (nearly 9 million), and the United Arab Emirates (8 million)[182].

International migrants are an increasing and sometimes significant share of the population in destination countries (Figure 8.9). This is the case especially for high-income countries and in the case of Middle East and North Africa. Lately however evidence indicates that destination

[182] Source needed

countries are slowly changing as for example China becomes more attractive for them. Still though, High-income countries are net recipients and South, East Asia and the Pacific net senders by far (Figure 8.10).

Figure 10.6: International migrants (percent of population in recipient countries)



Source: FAO calculations (data from the World Development Indicators, World Bank)

With the recent migration flows from the Near East and North African region, international migration has received renewed and broad attention. But migration is not a new phenomenon, it has accompanied human development for millennia. Nor are the causes of international migration new. They have always included the desire to improve living conditions and livelihoods, escape from wars and conflicts, ethnic tensions, religious persecution, discrimination and poor governance, natural disasters and changing ecological conditions, competition for natural resources, population pressures, or simply the desire to escape poverty, hunger or outright starvation. Usually, internal or international migrants are a vibrant, dynamic, younger, well-educated and wealthier part of the sending societies looking for better opportunities for themselves and their families[183].

Recently, a number of international migration flows have risen particularly fast. Important recent flows include the vast outflows from the Middle East and those from sub-Saharan and Northern Africa to Europe. The most frequently cited reasons for the former flow are conflicts, war or civil strife, those for the latter often pertain to economic reasons, including the growing resource scarcity and resource degradation, deteriorating livelihoods, and as a consequence, food security. While the definition of migration is not unambiguous, for analytical purposes it may be useful to distinguish between the short-term flows often caused by different forms of violence from the longer-term flows, frequently caused by population pressures, resource scarcity, degradation and deprivation or protracted conflicts and crises.

Also the structural transformation of economies including, the agricultural and food system transition generates migrations across geographic territories. For a significant part, in low-

[183] Evidence or references needed

income countries, migration coincides with exit from agriculture and movements to rural cities or major urban areas, in the services and manufacturing or industries sectors. Poverty and differences in wages between sectors, rural and urban areas or among countries; cash constraints, risk sharing and income diversification, insecurities, shocks and localized or widespread crises, motivate or force people to migrate temporarily or for their lifetimes[184].

While population growth is expected to slow down at the global level, a number of countries will be confronted with an almost unabated growth of their populations. Table has identified the countries with the highest percentage growth rates in the future. By 2050, the populations of these 13 countries will have more than doubled from 320 to 835 million and it is expected to more than redouble to 1.8 billion by the year 2100. Should these projections materialize, larger outmigration, particularly from resource-poor countries, appears unavoidable. This is particularly the case for the resource poor countries such as Niger or Mali. Moreover, as essentially all of these countries are projected to be adversely affected by the impacts of climate change, these outflows are likely to intensify as the impacts of climate change become more noticeable. The combination of high population pressure and growing resource scarcity could create new or add to existing conflicts and hence reinforce a vicious circle of population and resource pressure, conflict and protracted crises, and internal and international migration.

Social challenges also emerge when populations in recipient countries perceive migrants as competition for jobs (especially for low skill activities) and as threat for the level of the wages earned. Considering however ageing populations and low fertility rates in many regions especially in high-income countries, migration can provide substantial benefits for both sending and recipient countries in mid or long term perspectives. However a significant part of international migration refers to South to South, North to South and North to North mobility (Table 8.2). Policies and frameworks at national and international levels will have to manage the labor transition and migration flows so that they are smooth, match needs and avoid losses emerging from informality.

Migrants fund their journeys and the initial phases of transition with own or family resources. In exchange, they provide remittances, or just reduce help by reducing the number of people that needs to be fed and supported or find employment in the locations of origin. In addition, they assist in building a network for others to follow. Remittance receipts amounted to $US 600 billion in 2015 (Figure 10.10). Plenty of evidence indicates that migration and remittances contribute to resolving liquidity constraints reduce risks, increase investments and eventually productivity in both sending and recipient areas and sectors. However, significant constraints remain in reducing the costs of sending remittances especially in sub-Saharan Africa.

[184] Evidence or reference missing

Figure 10.7: Net international migration rates (millions of people)

Source: FAO calculations (data from the World Development Indicators, World Bank)

Transitions to productive and remunerative employment need to be supported by policies and frameworks, as many challenges make mobility paths difficult and painful. The means, skills, knowledge or networks necessary for migrants or youth to find employment are usually poor, the paths are not structured and informal processes dominate signifying efficiency losses for people themselves and the countries. Such efficiency losses mainly refer to foregone taxes due to informal or odd jobs. They also refer to social costs, dissatisfaction and unhappiness resulting not only during the transition but also from difficult conditions and exploitation in destinations.

Nevertheless, many constraints apply to migration and mobility of labour. The record of internal migration in Africa for example shows in cases, explicit or implicit policies and other barriers to labor mobility. Such policies refer to actual policy restrictions, (e.g. Ghana, Ethiopia or in China for an example outside Africa), and they extend to insecure land or other property rights or poor education. In India, limited rural to urban migration is attributed to little job creation in manufacturing even though mobility to off farm rural based activities is observed[185]. Urbanization trends in some sub-Saharan African countries are ascribed either to cyclical factors or to resource exports that provided resources to invest in urban areas and absorb labor in construction[186]. At individual or family levels, risk aversion, lack of information, poor social networks, communication and transportation infrastructure, opportunity costs or just dissatisfaction to undergo through the mobility costs, reduce migration.

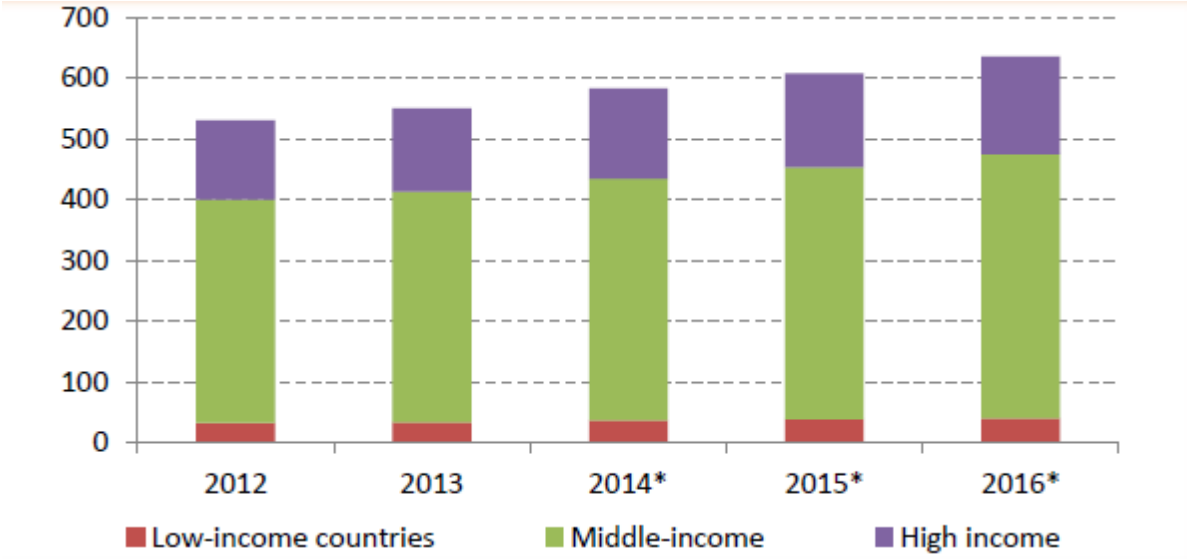
[185] Binswanger-Mkhize (2012)
[186] Jedweb () and DeBrauw at. Al (2013).

Table 10.2. Distribution of international migrants by origin and destination, 2013

Direction	Stock (millions)	Percent
South to South	82.3	35.5
South to North	81.9	35.4
North to North	53.7	23.2
North to South	13.7	5.9
Total	232	100

Source: UN-DESA, 2013

Figure 10.8. Remittances to low-, middle- and high-income countries, 2012-2016 (US billion dollars)



Source: World Bank (2013). *Forecast.

High rates of unemployment and underemployment are among the most relevant root causes of distress rural out-migration. Available jobs in rural areas, and those in the agricultural sector in particular, are associated with low and insecure incomes, poor occupational safety and health (OSH) conditions, gender inequality in pay and opportunities, and limited access to social protection (FAO 2013b)[187]. Youths in agriculture often lack access to land, financial services, and participation opportunities in community decision-making processes.

In the next decade, persistent poverty, climatic threats and increasing competition for natural resources will fuel more distress migration. This is likely to further fuel:

- Loss of human capital, highly skilled workers and agricultural labour may affect crop production and food availability.

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

- Ageing and feminization of rural populations, as males tend to migrate more than females and increased work burdens on those left behind.
- Changes in land use and titling due to remittances enabling the conversion of agricultural land to land for housing, leading to rising land prices and falling agricultural production, which may affect food security.
- Irregular, precarious jobs, unsafe working conditions and weak access to social protection for migrant workers [S2][188].

However, internal or international migration can be poverty-reducing and development instrument for both origin and destination countries as long as efforts are undertaken to coordinate flows, reduce economic and social costs, promote decent employment, but also support the matching of skills demanded with those supplied[189].

An important consideration refers to labor mobility and transition that is able to match skills and capacities demanded with the ones supplied. Firm level surveys indicate that in most traditionally destinations countries there are constraints in filling positions of technicians, engineers, and sales representatives. These destinations refer to North America, Europe, North Africa and Middle East, including Asia and the Pacific as lately China is becoming a net recipient of migrants relative to the past. Capacities, skills and education is another constraint to be addressed. As per ILO, by 2020 there will be a 40 million potential shortage of workers with tertiary education, 45 million with lack of secondary education and 90 to 95 million oversupply of low skilled workers.

10.4 Feminization of agriculture

The policy debate about rural transformations and rural livelihoods diversification often miss to address the differential constraints that women in smallholder farming household face - lower human capital, inadequate wealth and access to assets, and more insecure property rights - constraints which significantly limit their abilities to respond to shocks or to economic opportunities.

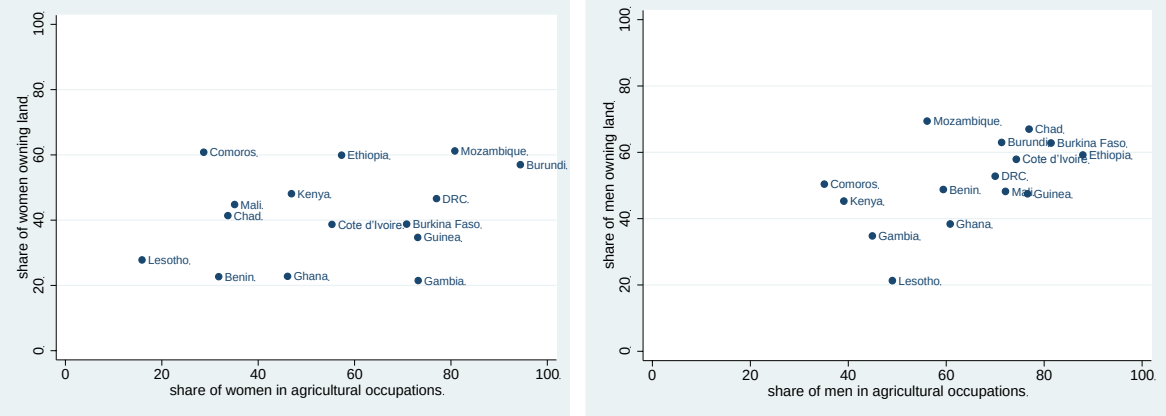
Across low-income countries, women are heavily involved in smallholder agriculture – often in a temporary and/or unpaid activities – and have poorer access to productive assets such as land and capital, inputs and technology, as well as services. Their decision-making capacity therefore remains limited, including in community decisions over natural resources (World Bank, 2009; FAO/AQUASTAT, 2016). Figure 3.8 shows that rural women in Sub-Saharan Africa are less likely to own land when engaging in agriculture. Women working in agriculture are also found to have less access to credits and agricultural inputs, which is hampering agricultural productivity growth. In Sub-Saharan Africa, agricultural productivity levels of female workers are between 20 to 30 percent lower than male workers because of the gender gap in access to resources, according to recent studies.[190]

[188] The paragraph builds upon the FAO position Paper on Migration. Zero Draft 24-06-2016. FAO

[189] In sub-Saharan Africa, research showed progress in poverty reduction resulting from migration within rural areas (from agriculture to rural towns) References needed

[190] Kilic, Talip, Amparo Palacios-Lopez and Markus Goldstein. 2014. "Caught in a Productivity Trap: A Distributional Perspective on Gender Differences in Malawian Agriculture." *World Development* 70: 416-463.

Figure 10.9 Land ownership against employment in agriculture, by gender



Source: Demographic and Health Surveys from rural areas, 2010-2015

Preferences and decisions over improved inputs for crop and livestock activities can vary substantially been men and women as well -- as one example, initiatives on agricultural technology adoption are often taken over by male farmers because of women's time constraints and norms that limit their ability to manage input and production decisions (World Development Report, 2012). More data is becoming available in this area, but further work is needed in terms of collecting gender-disaggregated data in agriculture across countries, and understanding outcomes experienced by men and women plot managers from climate and resource-related factors.

FAO's Gender and Land Rights database also highlights women's lower rights and security over land tenure across countries. Limited landownership tenure security can also constrain access to credit and services that ease investments in improved technology, natural resource management, and other cropping and livestock practices that can help in adapting to declining land quality (World Bank, 2009).

Women also face several constraints on their time use, which are often tied to local norms and beliefs that also affect their land rights, work stability, and the type of activities they can participate in. Women, for example, are heavily involved in collecting water and firewood, both for household consumption and agricultural use[191]. Decreased water quality also increases the risk of water-borne diseases, particularly for pregnant women and children, and also increases time spent on water treatment in addition to collection.

On firewood, as of 2010, 66 percent of households in Sub-Saharan Africa, 55 percent of households in South and South-East Asia, and 31 percent of households in Latin America rely on firewood collection for cooking, with women again being primarily responsible (UNDESA, 2010). Deforestation has substantially increased travel times to collect fuel as well. Poor rural women lacking secure land tenure also often depend on common property resources for fuelwood, food for livestock, and other resources.

In a recent study from Malawi, Asfaw and Maggio (2015) establish that weather shocks significantly reduce consumption and nutritional outcomes, with more pronounced effects where the share of land area owned by women is higher. The results point towards the

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

hypothesis of a gender-differentiated impact of drought shocks, which lead to a negative and consistent deviation on household's welfare when the gender indicator rises, suggesting that, in the case of high climate variability, women involved in agriculture are much more vulnerable than men and, consequently, less able to cope with shocks. These results point to the need for improved policy actions tackling increasing climate variability, with much more effort to protect the welfare of vulnerable groups.

As economies and rural areas transform, agricultural employment is expected to shrink with both women and men moving into other sectors. Yet, while men may diversify out of subsistence farming or agriculture altogether, in many low-income countries women continue to work in agriculture and diversify out of subsistence farming significantly slower. As men move out of the sector, women's roles in agriculture may actually expand, leading to concerns about feminization of the sector.

An ongoing review by the World Bank and FAO[192] attempts to assess the available evidence around the feminization of agriculture globally. The review identifies a great number of countries in the Near East and North Africa (NENA), Central Asia, South Asia and Latin America where the female share of agricultural employment has increased significantly in the last two-three decades or where women form the majority of employment in the sector, even if the share of female employment in the sector has not changed significantly in the last 2-3 decades. The significant rise of women's share in agriculture in many of the countries globally is too striking to be simply attributed to the higher visibility of women's work in statistics or different methods of data collection, though some of the variation across the years may still be driven by the data sources.

The trends towards agricultural feminization are especially prominent in the NENA region. The share of women in agriculture increased from about 30% in 1980 to 43% in 2010 in North Africa and from 35% to 48% in the same period in the Near East (FAO, 2011). Before the conflict started, in Syria the share of women in agricultural employment rose from about 30% in 1980 to more than 60% in 2010. Similarly, in Iraq and Morocco the share of women in agriculture rose from 30% to 50% in the same period. Between 1999 and 2013 in Armenia, the female share in agricultural employment increased from 45% to 59%. Diversification out of family farming due to demographic pressures and land fragmentation, intensification of agriculture affecting demands for male and female labour, the growth of jobs in other sectors, social norms around women's responsibilities in the sector and gendered ideologies are behind the striking rise of women's responsibilities in agriculture in the region.

The female share of agricultural employment is also on the rise in a number of countries in South and Central Asia. From 35% in 1980, the share of women in agriculture in Nepal increased to 50% in 2010 and some other sources suggest that the share of women in agriculture is as high as 60%. Male out-migration is the key driver of the rising role of women in agriculture in the country. Nearly all migrants from rural Nepal are young men. The women's share in agriculture is also increasing in Iran and Pakistan – in Iran women formed only a quarter of agricultural employment in 1980 and almost half of the employment in 2010; in Pakistan, from a meagre 12% in 1980 the female share in agricultural employment reached about 30% by 2010. Women are dominant in agriculture in some Central Asian countries as well. In Tajikistan, more

[192] The insights and the write-up in this section are fully adopted from a background paper conducted by the World Bank and FAO: Vanya Slavchevska, Susan Kaaria, and Sanna Liisa Taivalmaa. "Feminization of Agriculture in the Context of Rural Transformations: What is the Evidence?" Background paper, July 2016.

than 55% of the agricultural employment is female. Deteriorating economic conditions in rural Tajikistan push men to migrate for work to neighbouring Russia.

In the majority of countries in Sub-Saharan Africa women have always formed a significant share of agricultural employment and, therefore, the absence of significant jumps over the same period is not surprising. For example, the share of women in agriculture is 56% in Burundi, 59% in Malawi, 57% in Rwanda and Chad, 62% in Sierra Leone, 67% in Lesotho. Significant increases in the share of women in agriculture are still noted in a few countries - in Chad the share of women in agriculture increased from 30% to 57% in the last twenty years. In Botswana, women formed about 47% of the agricultural employment in 1980 and 57% in 2010.

A growth in women's employment in agriculture is even apparent in a number of Latin American countries, including Chile, Peru and Ecuador. In many countries in Latin America the observed changes in women's engagement in agriculture are likely driven by wage employment in agro-businesses around non-traditional agricultural exports (NTAE). Employment around NTAE are an opportunity to increase women's economic empowerment and expand the jobs available to rural women, but policies must ensure that these jobs are decent as abuses of women in the sector are well recorded.

Table 10.3. Female share of economically active in agriculture in 1980, 1995 and 2010

Country	1980	1995	2010
Africa			
Burundi	55.9	55.9	56
Comoros	50	50.3	52
Madagascar	54.7	53.9	53.5
Malawi	56.7	56.1	59.2
Mozambique	58.6	63.4	65.2
Rwanda	55.3	56.1	57
United Republic of Tanzania	53.7	54.1	55
Zimbabwe	54.3	55.3	53.3
Angola	52.4	52.6	55
Chad	28.9	50.8	56.9
Congo	56.6	60	56.5
Botswana	46.6	52.4	56.9
Lesotho	72	68.2	67.3
South Africa	37.1	31.1	29.6
Swaziland	58.5	60.7	54.3
Benin	34.5	41.1	39.6
Gambia	50.6	51.2	53.3
Mauritania	47.6	49.2	53.9
Senegal	44.9	45.5	47.4
Sierra Leone	59	58.5	61.7
Algeria	41.5	50.4	52.7
Libyan Arab Jamahiriya	37.2	50	69.9
Morocco	29	38.9	47.7
Sudan	32.5	32.9	39.5
Tunisia	27.1	34.4	32.8
Western Sahara	42.1	47.8	53.7
Asia			
Cambodia	57.3	54.9	51.2
Indonesia	33.7	39	39.3
Lao People's Democratic Republic	51.3	51.8	52.3

Country	1980	1995	2010
Viet Nam	50.7	51	49.1
Bangladesh	42.4	44.5	51
Bhutan	26.3	19.4	34.7
Iran (Islamic Republic of)	25.2	33.9	46.4
Nepal	35.4	42.2	48.1
Pakistan	12.2	18.4	29.6
Western Asia			
Azerbaijan		53.8	53.9
Iraq	29.7	38.2	50.3
Jordan	41.9	44.3	62.2
Occupied Palestinian Territory	64.8	64.1	72.5
Syrian Arab Republic	31.7	50.7	60.7
Turkey	40.4	48.2	52.3
Yemen	29.3	31.4	40.1
Latin America			
Chile	9.2	10.6	14.2
Colombia	19.5	19.9	24.8
Ecuador	14	17.6	24.8
Peru	19	27	31.3
Papua New Guinea	47.9	53.5	55.8

Source: Extracted from FAO 2011, Table A4: *The state of food and agriculture 2010-11. Women in Agriculture: Closing the gender gap for development*. Rome: Food and Agriculture Organization of the United Nations

The key drivers of agricultural feminization are male out-migration and the globalization of agri-food systems. However, there are other factors such as disease outbreaks, agro-technologies, conflict and climate change that impact women's work in agriculture, both directly and as contributing factors to migration and the availability of other jobs. Male out-migration affects women's role in agriculture through the loss of male able-bodied labour, which is mediated by the flow of remittances, or the lack thereof. The globalization of agri-food systems is expanding paid employment opportunities for women outside the family farms.

The increasing role of women in agriculture can be empowering if women increase decision making and control of resources in the household, but it may also exacerbate women's workloads, as infrastructure and institutions in low-income countries are rarely adapted to support working women. Successful migration and high remittances have the potential to boost agricultural production and women's empowerment, but migration is not always successful especially when urban areas cannot absorb the migrant population and the migrants do not have the capital to overcome the financial constraints of migrating abroad. When remittances are inadequate, women face higher workloads and financial difficulties, leading to increased workloads and reduced welfare. In addition, in commercial farms women are more likely to be concentrated in labour-intensive, low skilled jobs and the few managerial positions are more likely to be taken by men implying persistence of gender inequalities in the sector and insufficient gains in women's empowerment and welfare.

The review also raises the issue that to better track changes in women's status in agriculture and their welfare over time, there is a huge need for timely, high-quality, detailed sex-disaggregated data and such data are currently missing.

10.5 Annex: Regional structural changes and agricultural transition experiences

There is more than one path witnessing the experience of different countries in developing agriculture and the transition path of small-scale farmers during the process. The current patterns of structural change and agricultural transition are described below for each low-income region in order to show the diversity of paths but also the future challenges that need to be accommodated.

Sub-Saharan Africa

During the last decades, most countries in Sub-Sahara Africa experienced strong economic growth which contributed in increasing the total output in the region from USD 400 billion to above 1 trillion in 2014, but represented an increase of only 20 percent however in per capita terms. In this period of economic expansion, agriculture remains the major employer of the population accounting for just over 60% of jobs across the continent[193]. The contribution of agriculture in GDP remained virtually unchanged, and productivity growth in the sector remains quite weak and slow when compared with the record of all other low-income regions. A significant part of the increases in agricultural output the last decades came as a result of extensification rather than intensification. In addition, by many different accounts industrialization processes are weak but there is evidence of increasing output and shares of people employed in services.

Evidence indicates that recent strong economic growth rates are explained by trade liberalization, better macroeconomic policies, and improvements in the quality of institutions and governance structures relative to the past. However, progress in these factors, along with some example cases of socially inclusive policies and safety nets, and the associated economic expansion seem to translate only in poor or slow gains in terms of food security and nutrition. Despite some positive economic progress the process of structural transformation, remains static in its early stage and typical transitional changes which are initiated through urbanization, industrialization and employment creation have not been observed so far. Some studies show that African countries are even going through a path of "de-industrialization", with notably high shares of employment in the services sector and informal activities but without the creation of a major industry or manufacturing sector. . Agribusiness activities outside of farming account for 78% of total value added in all agricultural value chains globally, yet this figure falls to approximately 38% in Africa.

Many try to explain the slow progress in poverty and hunger alleviation in Africa, by arguing that most of the countries in the region are still tied with traditional economic structures and that economic transition dynamics are weak or lacking. This is mirrored by agriculture's small contribution to economic output, while the sector remains an important but stagnant employer to an increasing rural population. The weak transformation processes, limit the creation of decent/productive and remunerative employment opportunities and the diversification of income sources outside of agriculture in rural areas and in the formal sector and in industry in urban areas.

[193] AGRA, 'Africa Agriculture Status Report,' 2013. In AfDB FEED AFRICA: STRATEGY FOR AGRICULTURAL TRANSFORMATION IN AFRICA 2016-2025

In rural areas, households more frequently diversify their income engaging in off farm activities through increasingly engaging in low-productivity activities such as construction, transportation and services in the informal sectors. As a result productivity growth rates in agriculture and other sectors remain low, farm sizes continue to decline and an impressive number of about 200 million people will enter the labour force with meagre chances to find employment except from seasonal agricultural work or in the informal sector. Lack of infrastructure, low rural to urban migration rates and poor private investment rates, are also part of the challenge to advance the transformation and agricultural transition paths. These particular circumstances and multiple constraints in African countries will make it impossible to replicate the experiences and success stories of structural transformation of other low-income regions.

Finally, security of land tenure and good governance remain major challenges across the continent**.** Only 10% of Africa's rural land is registered, while inefficient land administration means that transferring land title deeds costs twice the price and takes twice as long as it does in high-income countries. Most African countries have basic land tenure laws that are incomplete and poorly enforced, deterring private investment. Applicable legislation remains voluntary and non-binding. Weak policy and institutional frameworks are the leading cause of corruption in the agriculture sector, including land administration. Meanwhile, women's access to land is on average less than half that of men. Generally, title and inheritance rights across Africa are bestowed to male family members. Yet women remain the primary users of agricultural land in most African communities (AGRA, 2013).

Middle East and North Africa

In recent years, the Middle East and North Africa (MENA) region is undergoing incisive political and economic transformation and has been afflicted by civil conflicts, violence, lack of security and social and political stability impacting economic development progress and food security. Different paths of transformation and economic development are found between oil exporting and non-oil exporting countries of the MENA region. In oil-exporting countries, industry is the major economic sector with increasing shares of GDP, whereas on the contrary, non-oil exporting countries heavily rely on an increasing service sector. Starting from an already marginal importance for the economy, the sectoral share of agriculture in GDP decreased at a fast pace during the 1970s and eventually slowed down from the beginning of the 1980s.

During the period of time from 1970 to 2006/07, agricultural labour productivity increased in several countries due to improved technology and innovation, but thereafter it started a downward trend. This trend was accompanied by increasing numbers of rural population engaging in agriculture and a steadily increasing agricultural output. Israel was one of the few countries that gradually increased its output while the absolute number of its rural population engaged in agriculture decreased.

Economic characteristics and differences within the region and between resource rich and non-oil exporting countries show that although structural transformation has happened at different levels, natural resource constraints such as availability of land and water are reasons for the low contribution of the agricultural sector to domestic food availability, thus creating an increasing dependency on food imports. Further challenges such as demographic pressure, rapid urbanization, water scarcity and climate change are affecting developments of social, political and economic transformation processes.

Latin America and the Caribbean

Over the past decades, countries in Latin America and the Caribbean are undergoing a significant structural economic transformation, including in the agricultural sector. The region experienced strong overall economic growth during the 1960s and 1970s (averaging around 6 percent per year), and significantly lower rates during the 1990s and 2000s (averaging 3 percent). The pathways of structural transformation and agricultural transition diverge across countries. In Brazil, one of the richest countries in the region, the share of agriculture in GDP remained stable at about 6 percent over the past twenty years, while the share of agricultural employment declined from 24 to 9 percent. In Mexico, agriculture's share in GDP fell from 7 percent in 1990 to 3.5 percent in 2013. The sector's employment share also halved during that period, falling from 12 to 6 percent.

Labour productivity in the sector, nearly doubled in both countries and more than quadrupled in Argentina, which also experienced transformative changes in the agriculture and the economy at large. Overall income and agricultural productivity growth contributed to declining poverty rates. Yet, in the early 1980s, there were 74 million rural poor among a total rural population of 124 million, and, 41 million of these could not meet their food needs. By 2010, numbers were 62 million, 119 million, and 39 million respectively. While some countries saw important reduction in rural poverty levels, most countries in the region have not been able to reduce the absolute number of poor in any significant way. High-income inequality has impeded greater trickling down of aggregate income growth towards the poor.

As a partial response to these trends, many countries in the region have put extensive safety nets and social protection programmes in place to provide income support to the poor and vulnerable, including smallholder farmers. These have helped accelerate reductions in food insecurity, malnutrition, and poverty, while also contributing to reductions in income inequality during the 2000s.

South Asia

In the last decades countries in South Asia are experiencing significant economic growth, sectoral and social and structural changes. The region demonstrated steadily high average GDP growth rates about 7 per cent during the last decade, whereas average growth rates during the 1980s and 1990s were about 5 per cent. While the contribution of agriculture in the overall economic output declined between 1970 and 2012 (from 42 to 19 per cent), the services sector has grown gradually with a share of GDP from 38 to 51 per cent in the same period. These changes correspond to only a small decline of the share of employment in agriculture in total employment, from 59 to 47 per cent between 1994 and 2012, a small increase in the share of employment in services from 25 to 28 per cent and in industry from 16 to 25 per cent.

The paths of structural transformation in South Asia are quite diverse across countries and overall transformation is slow in comparison to countries in East Asia. In most countries of South Asia the services sector is dominant and an industrial sector never fully developed, thus industrialization as it happened in other countries that experienced structural transformation has not emerged. In addition, an increase of overall productivity through the shift of low to high-productivity employment is lagging behind in countries in South Asia. For example, in India, the most populated and largest country in the region, the share of agriculture in GDP declined gradually in the last two decades from 29 to 18 per cent during 1990 and 2012, while the sector

still employs the majority of India's work force, 47 per cent of total employment declining from 61 per cent in 1994.

The agricultural sector is also the most important sector employing the majority of economically active people in Bangladesh, Bhutan and Pakistan with shares ranging from 44 to 62 per cent, although GDP shares of agriculture value added are also falling. Such wide gaps between decreasing agricultural output and high numbers of people working in the sector coincide with low rates of growth in agricultural productivity. Indeed the annual average growth of agriculture value added per worker ranges between 0 to 2.2 percent per annum in all countries of South Asia, except for Bangladesh, where it reaches annual average growth of 3.7 per cent. In India and Nepal, agricultural growth per worker was stagnant and even declined in Pakistan between 1990 and 2011. In the case of Bangladesh and Sri Lanka, the rapid spread of mechanization in agriculture might have contributed to its productivity growth, and even had a positive indirect effect on local manufacturing. India's slow agriculture transition however is also reflected by the limited use of mechanization in agriculture. Overall, the region shows diverse paths of small or large-scale mechanization in the sector.

Although services, manufacturing and industry are increasingly contributing to GDP, they were not be able to absorb the growing workforce resulting from demographic pressure, and thus unemployment rates increased between 1990 and 2012 in all countries except for India, Pakistan and Sri Lanka. As an ever-increasing part of a population of over 1.7 billion in 2014, is searching for employment opportunities within the economy and in higher productivity sectors, the absolute number of people active in the agricultural sector and rural population are increasing in South Asia. The reason for insufficient employment opportunities are unbalanced sectoral changes and slow agricultural transition, which additionally are negatively influenced by inadequate infrastructure, thus impeding further rural transformation within the region. Population growth in rural areas and insufficient employment opportunities may also be push factors for the rural population to move to urban areas, find better employment opportunities and work in manufacturing industries and services as wages are higher in these sectors. Thus rapid urbanization and rural-urban transition may have positive impacts on mobility and welfare improvements.

South Asia has shown fast declining poverty rates from 51 to 19 per cent between 1990 and 2012 and declining rates of prevalence of undernourishment from 25 to 16 per cent. Pakistan, Sri Lanka, Nepal and the Maldives were most successful in reducing their poverty rates, whereas Bangladesh and India depict the highest poverty rates in the region with 44 and 21 per cent respectively. However, additional challenges that impede the process of structural transformation in South Asia are rising inequalities, which create not only marginalization and exclusion, but make it difficult to further accelerate the process of alleviating food insecurity and poverty.

South-East Asia

Countries within the Southeast Asian region are quite diverse in their economic, social and cultural structure. Most of them have achieved to maintain high economic growth rates and have been successful in the process of rapid rural transformation in the last decades. In most of the countries in the region agriculture played an important role in initiating this process of transformation and economic growth. Beginning in the 1960s and 70s, the Green Revolution brought new varieties and new technologies leading to a rapid increase in output and yields of

rice and wheat thus contributing to agricultural growth. Also government investments, a strong support for smallholder agriculture and agrarian reforms throughout this period of time until the late 90s paved the way for other industries to develop. Despite the economic crises in the 1990s and 2000s which hit the economies in the region, rapid economic growth continued and recent GDP growth rates are 5 per cent at average (in 2014), slowing down from a constant rate of 6 per cent between 2000 and 2010. Even higher GDP growth rates mainly occurred in the 1970s with over 7 per cent. During these decades, most of the region's GDP growth is driven by growth in the services and industry sectors. While GDP per capita is increasing, the share of agriculture value added in GDP is declining and already decreased by half from the beginning of the 1990s until 2014, accounting now for about 20 per cent of GDP.

Even though land in Southeast Asia is scarce and farm size remains quite small, the agricultural sector still employs a high share of the population, reaching from only 1 per cent in Singapore, 13 per cent in Malaysia and up to 71 per cent in Lao PDR. Nevertheless, employment shares in agriculture follow the downward trend of agricultural shares in GDP. Rapidly decreasing shares of employment in agriculture can be observed in Malaysia, the Philippines and Thailand. Ever more rural households seek income opportunities outside the agricultural sector and engage in rural off-farm activities in other economic sectors. This labour movement is also caused by a rapidly increasing share of the total population migrating to and now living in urban areas. Until recently the average share of the population living in rural areas has been higher than the share of the total population living in urban areas. These shares are now both equally high about 50 per cent, but show a clear tendency of rapidly increasing urban population shares outpacing current rural population shares.

In addition, the dietary transformation led by changing consumer preferences (in urban as well as rural areas) was followed by higher diversity of agriculture production and lower rice consumption. Consequently, production of products from animal sources and palm oil increased rapidly. Moreover, growing urban areas and an increasing population put further pressure on available land for agriculture in the region. As labour force and advanced technological inputs were used to increase agriculture output, labour productivity increased more rapidly than land productivity. The annual average agricultural labour productivity (agricultural value added per worker) more than doubled in the period of time between 1990-1999 and 2000-2011 for all countries of the region, except for Lao PDR and Vietnam for which numbers show a reverse trend. Studies show that Indonesia and Thailand were even able to improve both, labour and land productivity throughout a longer period from 1961 and 2010. Although agricultural transformation was accelerating in earlier decades through improved inputs and technologies, further agricultural productivity growth and structural transformation may be limited by an insufficient absorption of work force in productive activities and stagnant or declining rural wages.

Economic growth has led to reduced poverty across the region, and food security has also improved since the early 1990s, with undernourishment decreasing from over 30 percent in 1991 to less than 10 percent in 2015. The greatest decline in poverty rates has been witnessed for Vietnam, followed by Cambodia and Indonesia and Lao PDR, while countries like Malaysia and Thailand started with relatively lower poverty rates in the early 1990s. The highest rural poverty rates available for the region in 2012 are found in Cambodia (20.8 percent), Lao PDR (28.6 percent) and Vietnam (22.1 percent). Nevertheless, despite progress in terms of reduced poverty, vulnerability remains high in the region. Many people live just above the poverty line and risk falling back due to even small shocks to their livelihoods. Climate change and natural

disasters are contributing to people's vulnerability in the region, as is low public health expenditure.

A key labor market challenge, which is common to many South East Asian countries, is the lack of skilled labor, which represents a major constrain to employers, and impedes sustained economic growth in the region. Following a peak in unemployment rates in the late 1990s and early 2000s, there has been a downwards trend in the past decade, with rates have falling most rapidly in the Philippines and Indonesia, where rates however remain high by regional standards; around 6 to 7 percent of the total labor force. In addition, rising inequalities, poor infrastructure and poor governance present additional obstacles to the sustainable process of structural transformation in Southeast Asia, making the effort to eliminate hunger and poverty more challenging.

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11 Changing Food systems

Urbanization, the exit of labour from agriculture, and a decrease in agriculture's contribution to GDP have characterized, historically, the structural transformation of socio-economic systems (see Trend 2). In today's high-income countries, this process led to the emergence of an urban middle class and a massive shift in food preferences towards meat and dairy products. Although evidence is still sparse and studies are ongoing, the same process appears to be occurring now in low- and middle-income countries. At the same time, demographic pressure in these countries is increasing. Together, these dynamics change food systems in various ways, and these changes, in turn, drive further structural transformation.

While population growth increases the demand for agricultural products and stimulates farming activities, urbanization requires food that is more easily stored and transported. Food processing has thus become a key factor in the transformation of food systems. It requires the standardization of agricultural output, which in turn may require a concentration of primary production and the consolidation of farm land. Smallholder farmers may become landless agricultural workers, or migrate to towns and cities in search of employment, which accelerates urbanization.

11.1 Integrated and capital-intensive supply chains challenge smallholders.

Supply chains are increasingly characterized by the integration of primary production, processing and distribution, the automation of large-scale processing, and higher capital and knowledge intensities. Modern food supply chains have evolved primarily to provision urban and peri-urban supermarkets. In Latin America, early, rapid urbanization has led to profound changes in food production and distribution systems, with supermarkets now accounting for more than 50 percent of all food sold. In much of Asia, most food purchases in urban areas are now made in modern retail establishments, especially supermarkets[194].

While offering opportunities for generating formal employment, the modernization of agri-food chains in low- and middle-income countries has, in many cases, created serious barriers to the participation of smallholder producers and small-scale agro-processors in local, national and global markets. This has undermined farmers' livelihoods and their ability to diversify into other rural off-farm activities, which hinders inclusive rural transformation.

For many small-scale operators, issues of financing, market accessibility and transport, as well as the range of standards related to quality, traceability and certification, make participation in integrated value chains difficult, if not impossible. The concentration of purchasing power in the hands of a few supermarket chains allows them to require that suppliers maintain large stocks[195]. This helps supermarkets to respond quickly to fluctuations

194Reardon Thomas, Peter Timmer, C. Barrett, and Julio Berdegué (2003), 'The rise of supermarkets in Africa, Asia, and Latin America.' *American. Journal of Agricultural Economics*. **85:** 1140–1146.

[195]Peter Timmer. 2014. *Managing Structural Transformation: A Political Economy Approach*. UNU-WIDER Annual Lecture 18. Helsinki, United Nations University World Institute for Development Economics Research.

in demand, which stabilizes prices. However, economic agents with weak negotiating power bear the cost of market adjustments. For the losers in these situations, it may not be easy to find new income generating opportunities within the food system or employment outside the system.

Smallholder farmers benefit from the transformation of food systems when they are able to join formal and structured value chains through fair contracts with processors and traders. In recent decades, a number of business models, national and international value chain organizations, and institutional arrangements and policies have been developed to provide incentives and support services, such as credit, to smallholders, with the aim of increasing sustainable food production and facilitating market access.

The innovations include institutional and market intermediaries – e.g. participatory guarantee systems, marketing cooperatives, training centres, private traders and local public procurement mechanisms – which take on a wide range of roles in linking farmers to markets. The strengthening of local infrastructure, organizations and institutions is important for enabling small farmers and small processors to increase their share of value addition in the food chain.

11.2 Structured supply chains have far-reaching implications for dietary patterns, nutrition and health.

As well as increasing the efficiency of product flows – from the supply of farm inputs to the delivery of produce to retail outlets – these chains ensure food quality and safety, which benefits consumer health. At the same time, they facilitate the diversification of diets among more affluent consumers, accelerating the shift from starchy staples, which are the main foods of the poor, to livestock products, fats and oils, and fruit and vegetables. More affluent consumers tend to adopt globally connected lifestyles that increase the demand for novel foods.

However, industrialized meat production and the increased consumption of processed foods also raise concerns related to nutrition, the environment, food security and food safety. If processing and distribution systems are concentrated in urban areas and focused on more affluent consumers' preferences, remote areas may be excluded from the benefits, with negative impacts on their food security.

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

Meanwhile, the modern food economy is becoming more responsive to growing consumer demand for specific food items, which reflects income growth, age structure, levels of urbanization and changing tastes. Increasingly, food suppliers study the evolution of food

demand in order to plan food chain investments more effectively, from input supply to consumption[196].

To understand people's dietary behaviour, and how that behaviour impacts their health, it is important to understand the food environment. Research on this topic is in its infancy, but there is a widely held view that food environments are shaped by different 'domains' within the food system, including agro-industrial and market systems. This underscores the need for policies and strategies that not only promote agro-industrial and value chain development, but also take into account issues of efficiency, equity, sustainability, inclusiveness and nutritional outcomes.

Efforts to improve the efficiency of agricultural value chains and achieve sustainable food security and nutrition are constrained by discrimination against rural women. Across all developing regions, women play important roles in food production and value addition, and shoulder primary responsibility for the unpaid care of family members. Mothers usually choose what the youngest children eat, and women often have the most influence in determining what the whole family eats.

Women's knowledge, education, social status, health and nutrition, and their control over resources are key factors that affect nutritional outcomes. Many studies show that women's social and economic empowerment – the result of improved education or access to regular income – is one of the most relevant factors contributing to improved children's health and nutrition. Unfortunately, the persistence of gender-based discrimination means that women do not benefit equally from agri-food value chain development. They remain trapped in the low-skilled and low-paid nodes of the chain, often in casual and insecure employment. Ensuring that women benefit more from value chains is an effective way of empowering them economically and socially, and enhancing their capacity to contribute to household and community food security and nutrition[197].

11.3 Longer food supply chains have a larger ecological footprint.

As the pressure on scarce land and water resources increases, the agri-food sector must find ways of reducing its impact on the environment, which includes greenhouse gas (GHG) emissions, water usage, food loss and waste, and its effects on soil health, ecosystem services and biodiversity.

Changes in food supply chains are associated with higher GHG emissions from both production inputs (e.g. fertilizers, machinery, pesticides, veterinary products and transport) and activities beyond the farmgate (e.g. transportation, processing and retailing). By one estimate, in 2005, the production of fertilizers, herbicides and pesticides, along with emissions from fossil fuels used in the field, represented about 2 percent of global GHG emissions.[198]

Global value chains have substantially increased the use of long-distance transport between primary production, processing and consumption. In most instances, food that is transported long distances has higher rates of GHG emissions per unit of output, compared to the same food when produced by local food systems. When post-harvest operations are included,

[196]Peter Timmer. 2014. *Ibidem*
[197]Evidence needed
[198]HLPE (High Level Panel of Experts). 2012. *Food security and climate change.* A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

emissions totalling around 3.4 gigatonnes of carbon dioxide equivalent (Gt CO_2-eq) are caused by direct and indirect energy use in the agri-food chain,[199] adding about 30 percent to the emissions generated by agriculture and forestry and land use change. Food systems currently consume an estimated 30 percent of the world's available energy, with more than 70 percent of that share being consumed beyond the farm gate.

Finally, food safety and quality standards imposed by supermarkets may lead to the discarding of food that is still safe for human consumption, representing an enormous waste of natural resources (see Trend 12). Therefore, the evolution of food systems needs to be assessed not only in terms of economic efficiency and capacity to improve food security, but also in terms of their environmental impacts along the entire food chain.

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

In recent years, sustainability concerns have shaped the emergence in high-income countries and in some areas of Latin America and Asia, of a preference for high quality local foods linked to traditions and culture. Increasingly, global food movements such as 'Slow Food' are promoting this holistic approach to food.[200]

A related development in the evolution of food systems is the growing potential of indigenous food systems and neglected crops to contribute to the diversification of diets away from the narrow food base of maize, rice, wheat, barley and soybean. The recent appearance in mainstream food markets of indigenous foods, such as quinoa, amaranthus, chia, argan oil and moringa, highlights the potential.

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

While several indigenous foods (e.g. olluco, sweet potato, yam, kiwicha and native palms in the Andes and Pacific islands) could contribute significantly to the global food supply, it is unlikely that they will become major food commodities without further research and adaptation. However, indigenous foods can play a pivotal role in rethinking the way in which local food systems relate to the environment and intersect with markets.

Indigenous food systems are people-centred and manage the environment in a sustainable way. They also combine the consumption of produce with the purchase and sale of food, avoiding a fully commercial orientation. These features have appeared only recently in modern food chains, through production systems, such as organic farming, permaculture and biodynamic agriculture, that reflect to some extent the philosophical approaches of indigenous and traditional societies.

While modern food systems rely heavily on a few edible plant species and varieties, indigenous systems make use of several hundred edible and nutritious plants. The traditional knowledge which underpins indigenous systems is important for two main reasons. First, indigenous 'superfoods' – whose nutrient qualities make them highly sought after by urban consumers – could address some of the nutritional deficiencies that currently affect more than

[199]FAO. 2011. *'Energy-Smart' Food for People and Climate* – An Issue Paper. Rome.
[200]http://www.slowfood.com/

2 billion people. Second, the production of local plants that are usually consumed in the wild or with minimal domestication could be scaled up using modern technologies. This is already the case in the bio-cosmetic and pharmaceutical industries, which rely heavily on indigenous knowledge of plants and the medicinal properties of forest products. Similar alliances, if developed for food production, could greatly expand the present, narrow food base. However, it is important to protect the rights of indigenous peoples over their knowledge and its use.

11.5 Indigenous food systems are influencing mainstream food thinking.

They challenge the dominant food culture, which is focused on quantity and availability rather than on the inherent characteristics of a food itself. The rapid increase in non-communicable diseases linked to diets, as well as overweight and obesity, has increased awareness of the need to consider what food is produced, how it is produced, and how it is processed.

It is very likely that mixed systems will emerge in the coming years, with some indigenous food producers making more intensive use of technology. This will help to connect isolated, local food systems with global markets as urban demand grows for the next nutritious 'superfood'. Modern communications – mobile phones, internet and satellites – and self-certification will facilitate market access and reduce the need for intermediaries, thus allowing producers to capture a bigger share of the final product's added value.

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

However, indigenous food systems are face a number of threats, including: the destruction of habitats and the displacement of indigenous peoples from their lands; the loss of languages and culture in indigenous communities; the migration of youth to cities as older generations disappear; the loss of traditional seeds; and the rapid shift in food habits among the young, who are influenced by marketing campaigns for processed foods.

Anecdotal evidence indicates that indigenous youth are progressively abandoning their food systems. Knowledge about thousands of edible and medicinal plants, which has been built up over centuries of trial and error, could be lost forever, along with the forests, mangroves, lakes, savannas, pastures and mountain ecosystems that host them.

12 Food losses and waste

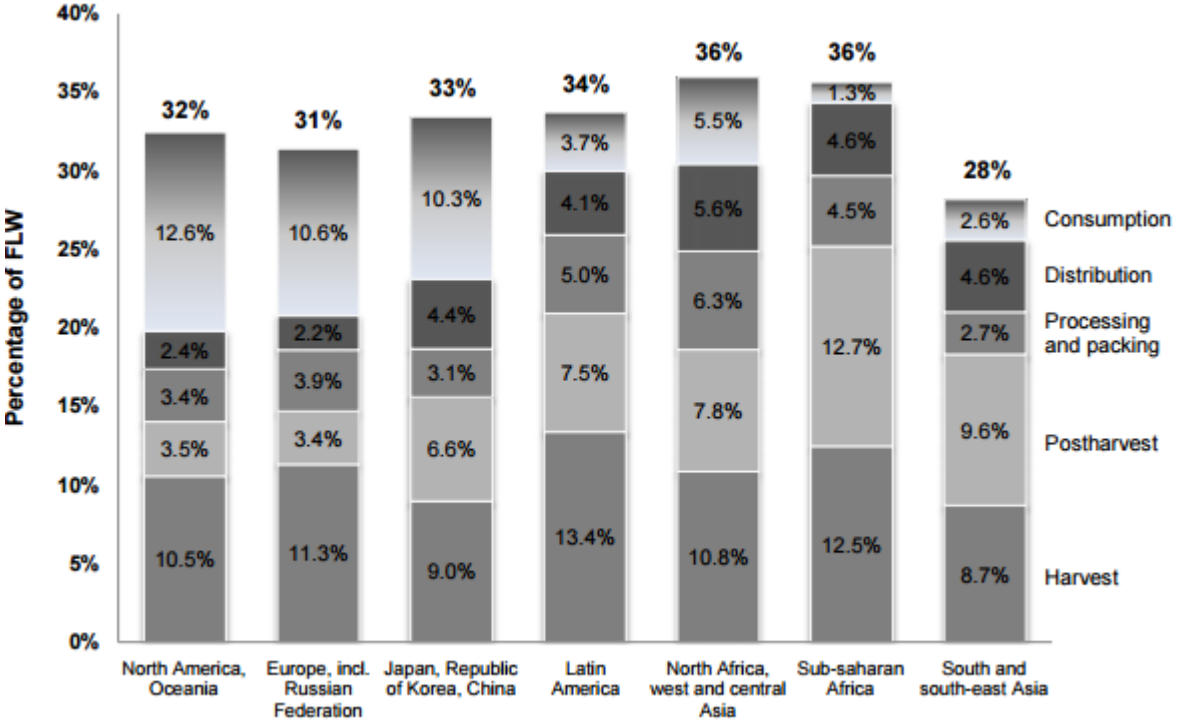
Magnitude and location. Observed levels of food losses and waste (FLW) suggest that food systems are not efficient[201]. FAO has estimated that every year roughly one-third of the edible parts of food produced for human consumption is lost,[202] representing an enormous waste of the land, water, energy and inputs used to produce it and unnecessary emissions of millions of tonnes of greenhouse gases. In low-income countries, food losses occur throughout food value chains, and result from managerial and technical limitations in harvesting, storage, transportation, processing, packaging and marketing.[203] The heaviest losses are in the small and medium-scale agricultural and fisheries production and processing sectors. Food waste in middle and high-income countries is caused mainly by consumer behaviour and by policies and regulations that address other sectoral priorities. For example, agricultural subsidies may encourage the production of surplus food crops, which reduces both prices and the attention that is paid – along the value chain and by consumers – to food losses and waste. Furthermore, food safety and quality standards may remove food from the supply chain that is still safe for human consumption. At the consumer level, inadequate planning of purchases and failure to use food before its expiry date also lead to food waste.

[201] This subsection heavily borrow from Bellù L.G. (2016): Food Losses and Waste: Issues and Policy Options. FAO UN Forthcoming.

[202] FAO. 2011. *Global food losses and food waste: Extent, causes and prevention*. Rome.

[203] HLPE (High Level Panel of Experts). 2014. *Food losses and waste in the context of sustainable food systems*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

Figure 12.1 Distribution of FLW along the food chain in the different world regions



Source: HLPE (2014), based on Gustavson (2011)

As a general trend, low-income countries suffer more food losses during agricultural production due to poor infrastructure, low levels of technology and low investment in the food production systems, abetted by uncertainty in weather and market conditions and weak institutional framework. Food waste at the retail and consumer level tends to be higher in middle- and high-income regions—where it accounts for 31-39 per cent of total food losses and waste along the whole food chain of those regions, compared with 4-16 percent in low-income countries (figure 12.1). Food waste is most often caused by both retailers and consumers over-purchasing and throwing away perfectly edible foodstuffs. Per capita waste by consumers is between 95-115 kg a year in Europe and North America, while consumers in sub-Saharan Africa and South and Southeast Asia each throw away only 6-11 kg a year (Gustavsson, 2011).

For instance, food waste at retail and consumer level only, is estimated in the United States of America at more than 60 million tons per year i.e. 31 per cent of the total available food at that food chain level, corresponding to around 1,250 calories per capita per day (Buxby et al. 2014)[204]. The European Commission reports that more than 100 million tons per year are wasted in the European Union[205]. Industrialized and less industrialized countries dissipate roughly the same quantities of food, respectively 670 and 630 million tons (Gustavsson, 2011).[206] In Africa, around 13 million tons per year of cereals, i.e. more than 15% of the total, are lost in post-harvest operations only (APHLIS, 2016)[207]. Attempts were made to quantify

[204] . Buzby, Jean C, Wells H. F. , and Hyman J. (2014) Estimated Food Loss at the Retail and Consumer Levels in the United States. Economic Information Bulletin No. (EIB-121) USDA-ERS. http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib121.aspx

[205] European Commission, Health and food safety http://ec.europa.eu/food/safety/food_waste/index_en.htm

[206] Gustavsson, J., et al. (2011). Global Food Losses and Food Waste. Extent causes and prevention. FAO UN Rome.

[207] African Post-Harvest Losses Information system (APHLIS): http://www.aphlis.net. EU Joint Research Centre –JRC et al. Five-year average 2008-2012, author's calculations.

some global environmental impacts such as the total carbon emissions, land and water use and biodiversity. For instance, FAO (2013) estimates that FLW generate more than 3.3 giga tons of CO2 equivalent/year (ref. 2007), corresponding to, e.g., all annual CO2 emissions of Russia and Japan together.

Definitions of FLW. Different studies use different definitions and estimation methods to assess FLW, refer to non-homogeneous segments of the value chains or use as unit of measure the weight in tons, which does not necessarily reflect the forgone benefits due to FLW. Therefore, an up-to-date global picture of FLW is difficult to obtain[208]. To overcome difficulties in measuring and comparing the "Food Loss & Waste Protocol", a multi-stakeholder effort to develop global accounting and reporting standards (known as the *FLW Standard*) has been set up. The first version of the standards is due in June 2016[209].

Despite objective difficulties in measuring *FLW*, there is enough evidence on the magnitude of *FLW* to raise the concern of the development community regarding their impacts on the sustainable use of natural resources and the current and future food and nutrition security. For instance, "*Zero Food loss and waste*" is one of the pillars of the "*Zero Hunger Challenge*", launched by the UN Secretary General in 2012, reinvigorated by the Agenda 2030 on Sustainable Development Goals (SDGs).

The renewed focus on *FLW* in the SDGs requires also renewed attention on research, measurement, monitoring and actions for *FLW* reduction. For instance, to address knowledge gaps, raise awareness and operationalize *FLW* reduction through policies, programmes and projects, global public-private partnership initiatives have been launched, such as the *Global Initiative on Food Loss and Waste Reduction* (Save Food Initiative)[210]. This is an umbrella public-private partnership hosting various global, regional and international programmes aimed at *FLW* reduction. FAO is also working on a *"Global Food Loss Index (GFLI)"* indicator, based on the calories content of food as a common unit of measure[211].

In an attempt to clarify what "*Food Losses*" and "*Food waste*" refer to, FAO has provided the following definitions:[212]

[208] For instance, FAOSTAT, the FAO global database of food and agriculture (http://faostat3.fao.org/home/E) report Waste by commodity country and year as an item of the so called "commodity balance sheets". Figures in FAOSTAT exclude waste before and during harvest, waste at household level and wastes occurring in processing, as they are embedded in extraction rates. In addition, they are often calculated as a fixed percentage of availability, the latter being defined as production plus imports plus stock withdraw (see FAOSTAT glossary). This makes comparisons of waste data from FAOSTAT not directly comparable with other data provided by global and regional studies.

[209] The FLW Protocol is coordinated by the World Resources Institute (WRI) and comprises the *Consumer Goods Forum* (CGF), FAO UN, the EU funded project *Food Use for Social Innovation by Optimising Waste Prevention Strategies* (FUSIONS), UNEP, the *World Business Council for Sustainable Development* (WBCSD), and the UK-based charity WRAP. www.wri.org/food/protocol

[210] The *Save Food Initiative* is a joint programme between FAO and *Messe Dusseldorf*, a German exhibitions company, involving private and public partners aimed at achieving FLW reductions. http://www.fao.org/save-food/en

[211] The *GFLI* index covers losses at farm, transport, storage and processing levels, although waste at household level is still excluded. FAO UN Technical Platform on the Measurement and Reduction of Food Loss and Waste. http://www.fao.org/platform-food-loss-waste/en/ .

[212] FAO's definitions of Food Losses and Waste. FAO UN Technical Platform on the Measurement and Reduction of Food Loss and Waste (extraction on 14 October 2016). http://www.fao.org/platform-food-loss-waste/en/ .

- *Food losses (FL)*: "decrease in quantity or quality of food" reflected in nutritional value, economic value or food safety of all food produced for human consumption but not eaten by humans".
- Food waste (FW): "part of food loss and refers to discarding or alternative (non-food) use of safe and nutritious food for human consumption all along food supply chains".

These definitions clearly state that *FW* is a component of *FL*. In addition, *FW* is characterized by an element of *deliberateness* (removal of food fit for consumption by choice or negligence). It is legitimate to interpret the complementary component of *FL* as something undesired, occurring for reasons not under the direct control of agents concerned, such as inadequate technology, poor logistics, malfunctioning of markets, etc.[213]. It is also worth noting that *FW*, "*predominantly, but not exclusively*" is associated to final consumption, thus recognizing that deliberate discarding of food may occur at all stages of the food supply chain.[214] FAO (2014) recognizes however that the difference between *FL* and *FW* "*is not defined sharply*" whereas this distinction is important because the underlying reasons causing FL and FW are very different. This implies that policies and strategies to reduce them have to be different as well.

Causes of FLW. To systematically investigate causes, impacts and solutions for *FLW*, the World Committee on Food Security (CFS, 2014) outlined a framework where causes of *FLW* are classified by *level*[215]:

- *Micro-level causes*: causes of *FLW* at a given stage of the food chain that result from actions of agents at the same stage of the chain (e.g. Poor harvest scheduling and timing, careless handling of produce, lack of appropriate storage conditions, careless transport, behavioral causes at consumer level).
- *Meso-level causes*: causes of *FLW* related to a whole food chain pertaining to decisions or missed decisions of agents in that chain (e.g. lack of coordination among segments, too long chains, missing product standards, pesticide-contaminated processed products)
- *Macro-level causes*. Causes of *FLW* that pertain to the overall socio-economic environment and reflect on the food chain micro and meso-level causes (lack of infrastructures, low educational level, missing legislative frameworks…).

General implications of FLW and related policies. Policies and strategies to reduce *FLW* must take into consideration the specific causes that generate them but they must be grounded on the recognition that, to a large extent, FLW are rational from a private perspective (see sections 3

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[213] In these definitions, there is a grey area associated to deliberate choices. Undesired reductions of output may occur, in many instances, as a consequence of deliberate choices not to invest to prevent them. For instance, deliberately deciding not to invest in storage facilities because the investment is not considered profitable may lead to reductions of outputs which are still undesired, although occurring as a consequence of a deliberate choice grounded on economic rationale. Being this an *indirectly* deliberate reduction of output, it could be classified as a food waste. A different situation may occur when an economic agent considers it profitable to invest in preventing food losses but he/she has no possibility to do that (e.g. for missing credit facilities). In this case, the reduction of output could be considered a loss, at least from the private agent's perspective.

[214] At least in principle, these new definitions do not limit the occurrence of *FW* at the end of the food chain (*distribution, sale and final consumption)* as for instance in Parfitt J., Barthel M., Macnaughton S. (2010). Food waste within food supply chains: quantification and potential for change to 2050, in Philosophical Transactions of Royal Society, Biological Sciences, Vol. 365, pp. 3065-81.

[215] CFS (2014). Report to the Committee on World Food Security (CFS) 2014 by the High-level panel of Experts on Food and Security Nutrition. www.fao.org/cfs/cfs-hlpe

and 4 below), as they are the result of the optimizing behaviour of agents (de Gorter, 2014).[216] However, from a societal perspective, i.e. from the point of view of the well-being of the whole society, *FLW* are claimed to generate net losses due to the associated socio-economic and environmental consequences, such as:

- *Lowering incomes for producers*. *FL* during harvest and in storage, other things being equal, translates into lost income for farmers, raising concerns for the poorest and most vulnerable.
- *Increasing food prices for consumers*. *FL*, by subtracting a share of supply, other things being equal, are likely to lead to higher food prices, negatively impacting poor consumers.
- *Squandering of resources*. *FLW* also amount to a squandering of resources, including water, land, energy, labor and capital and needlessly producing environmental damage including excessive greenhouse gas emissions, contributing to climate change.
- *Jeopardizing long-term food availability*. Increasing food requirements due to rising populations and incomes imply ensuring sustainable food production and consumption in the long run. *FLW* are claimed to endanger the sustainability of food systems.

Therefore, given the current decisional space available to private agents, i.e., considering the options currently available to producers, processors, traders, consumers, *FLW* may well be fully rationale. However, there are economic costs that individual economic agents do not consider in their decisional process, because of missing or imperfect markets, informational asymmetries, and negative externalities. As the society has to bear such costs, what is optimal by the private point of view results to be sub-optimal by the societal perspective. This divergence between private and social optimality suggest the need for policies to arrive at a socially optimal level of losses and waste.

Environmental implications of FLW. The most significant *trend* regarding food loss and waste (FLW) is the rapidly growing concern and attention for climate change and environmental sustainability in food systems. FLW have negative environmental impacts due to the water, soil, and other resources embedded in the food no one consumes, as well as contributions to biodiversity loss and greenhouse gas emission. These impacts can be expressed as the 'FLW Footprint' on the environment. For instance, studies have estimated that the agri-food sector currently accounts for around 30% of the world's total energy consumption, and that the energy embedded in global annual food losses is thought to be around 38% of the total final energy consumed by the whole food chain, which means that food loss accounts for more than 10% of the world's total energy consumption. Reducing FLW has also been identified as an important way to reduce GHG emissions from the food and agriculture sector without compromising food security.

There is more to be gained by FLW reduction than a mere reduction in its 'footprint'. For instance, more efficient systems that reduce losses or waste would likely result in reductions of GHG emissions. Direct reductions will occur since wastage typically generates methane emissions during food decomposition. The goal to reduce FLW require a critical redesign of food supply chains and retail models, which will result in less energy use along the food supply chain, and thus indirectly reducing GHG emissions. Generally, less FLW is associated with more efficiency and eventually more effective recycling of resources and less transport and

[216] A detailed discussion of the economic rationale of FLW can be found for instance in: De Gorter H. 2014: Food Waste and Losses: a study for FAO UN. Unpublished.

storage needs across long distances - all leading to savings in natural capital, less resource use and lower GHG emissions.

The *challenge* however is that solutions to reduce losses will often lead to an increased use of energy, especially for preservation of food products. The environmental cost of reducing food loss reduction must be carefully weighed against the benefits. Reducing food losses in a climate-smart way is contingent upon the deployment of climate technologies along the value chain, particularly for the processing and storage segments. There are many options available for both mitigation and adaptation technologies that can reduce food losses in low-income countries however little attention has been given to this topic. To have the highest impact, these technologies should also be gender-sensitive and easily accessible to women. Their limited access to technologies and services is in fact an important factors contributing to food losses along the supply chain.

Nevertheless, there is clear need for increased development, transfer and uptake of climate technologies for improving post-harvest management, which should be made available for women and men. Climate technology solutions to reduce food losses present an important opportunity to enhance climate action in food systems and tap into climate finance. FAO is in a strategic position to fill the gap between needs and opportunities and assist member countries in scaling up technology transfer and deployment to reduce food losses in the context of their domestic mitigation and adaptation priorities. This includes technologies all along the supply chain but particularly cold chains and food processing are of high priority because of the large mitigation potential and significant impact on food loss reduction. At the same time, the technology development should safeguard the nutritional value of the food products while contributing to reduce gender inequalities.

Specific behavioural aspects of food waste. Another *trend* is the growing concern and attention for food waste, which is a new topic for FAO. The practice and attitude by many retailers and consumers to throw away good food products is getting high on the political agenda in industrialized countries. In low-income countries, with the growing urbanization and supermarket chains, combined with 'western' lifestyles of consumers in cities, the occurrence of food waste is rising as well.

The *challenge* of food waste is that solutions have to be found, which cannot be based on technology but requires its own typical approach and intervention to change human attitude and behaviour, preventing food waste. In addition, there is the strategy of recovery and redistribution of safe and nutritious food, to save it from getting wasted.

13 Governance for food and nutrition security

With the implementation of the Millennium Development Goals (MDGs) between 2000 and 2015 came a growing awareness of the crucial role of responsible and effective governance in achieving key development objectives. This role is fully recognized in the 2030 Agenda for Sustainable Development, which constitutes a new charter for international cooperation and governance[217]. The radical reformulation of development means and ends, defined by the 2030 Agenda, finds parallels in the less visible, but equally profound, shift that has taken place in thinking about governance among governments, international institutions and the international expert community.

For the 2030 Agenda, all countries are 'developing countries'. The 2030 Agenda for Sustainable Development includes not only 17 Sustainable Development Goals (SDGs), 169 specific targets and 231 indicators for monitoring progress. Integral to the 2030 Agenda are the Addis Ababa Action Agenda on financing for development[218] (see Trend 15) and the Paris Agreement on climate change[219] (see Trend 4). It is supplemented by the outcomes of the World Humanitarian Summit.

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

Along with this profound conceptual change, there is a striking sense of urgency and *ambition* in the new sustainable development agenda, in terms of both the ends and the means. The aspirations of Agenda 2030 are transformative. It demands, as the first steps toward eliminating all forms of exclusion and inequality everywhere, an end to poverty, hunger and malnutrition, and universal access to health care, all with strong attention to gender issues; it seeks a global shift to sustainable consumption and production; it contains a legal instrument, the Paris Agreement on climate change, which commits all nations to taking steps to prevent global temperature rise above 2°C; and it includes a pervasive and demanding commitment to "leaving no one behind."

Underpinning the 2030 Agenda are radical new approaches to international cooperation and mutual accountability. A distinguishing characteristic of the agenda is its comprehensive view of the required means of implementation, which dramatically expands traditional financing for development to include new ways of facilitating low-income countries' access to markets, technology, capacity development and policy support. SDG 17, to revitalize the global

[217] Transforming our World: The 2030 Agenda for Sustainable Development (United Nations General Assembly Resolution A/Res/70/1).
[218] Addis Ababa Action Agenda of the Third International Conference on Financing for Development.
[219] The Paris Agreement (United Nations Framework Convention on Climate Change: Adoption of the Paris Agreement FCCC/CP/2015/L.9/Rev.1).

partnership for sustainable development, specifically addresses the need to strengthen the means of implementation, supported by the concrete policies and actions agreed in the Addis Ababa Agenda. Where traditional forms of international cooperation have been based on agreements between states, Agenda 2030 makes another important departure with its pronounced shift toward enabling collaboration between private sector and other non-state entities.

The new governance framework is shaped by six salient features. First, it implicitly recognizes that today no country is on a sustainable pathway, and that no country can achieve all of the goals on its own. The concept of development embraced by Agenda 2030 does not wholly set aside the North-South divide or the social dimensions of development. However, it brings to the fore a dimension of development that is universal in orientation, by insisting that all countries need to take steps – each within its own capabilities and in line with the ambitions of the new framework – to transition to new development pathways that are more inclusive, equitable, sustainable and climate-responsible.

Second, the global goals and targets are set from the 'bottom-up'. The SDGs were developed through a process initiated and controlled by Member States and organized according to the multilateral principle of sovereign equality. At the level of targets, each government is free to set its own national targets guided by the global level of ambition but taking into account national circumstances. Government ownership of the new agenda is the intended objective, and ensuring effective inter-governmental accountability for collective results becomes the critical challenge.

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

Fourth, at the core of the new agenda is a new, expanded vision of "'policy coherence". It recognizes development as an inherently complex process, which is possible only when public and private actors recognize the necessity of taking into account the mutual dependencies, constraints and trade-offs of action across sectors. Agenda 2030 rejects simple solutions, and promotes lateral, integrative and holistic thinking in the way it defines problems to be solved. This new vision comes at a price: in such a world, policy analysis, governance, and programme delivery are far more complex undertakings than those envisaged under the MDGs.

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

Fifth, the 2030 Agenda represents a different 'grand bargain'. The MDGs were a political 'grand bargain' between low- and middle-income countries, on one side, and high-income countries on the other. This was described in MDG 8 as a 'Partnership for Development' – in essence, a North-South accord between donors and their beneficiaries. In place of that historic

partnership, Agenda 2030 offers expanded cooperation to provide access to finance and investment, markets and technology, policy support and capacity development, but in a new context of partnerships dominated by private, and especially commercial, entities.

Finally, the 2030 Agenda establishes a different approach and level of commitment to 'mutual accountability'. In Agenda 2030, control over development finance is a much weaker source of policy bargaining than it was in the past. The demand of many low-income countries for policy space is amply recognized, not only with words but also through the massive expansion of targets and the freedom allowed to countries to establish their own national targets. In place of the finance-centred mechanism of the MDGs, Agenda 2030 posits a multilateral mechanism for mutual accountability: a new and expansive global framework for reporting on 231 unique indicators; monitoring commitments, policies and experiences, with analysis and evaluation by specialized intergovernmental bodies; and local, national, regional and global follow-up and review by political decision-makers at all levels.

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

The Organization may need to draw more deeply on its own experiences and those of others to ask: how it can become a trusted and effective facilitator and enabler of the ambitious and accountable partnerships that Agenda 2030 demands. FAO is asked consider again how best to balance its global role in providing data, norms and standards with its crucial mandate to foster transformational change. Most challenging of all, Agenda 2030 compels FAO to evaluate its contribution to, and collaboration with, the many other actors that constitute the United Nations development system, in particular the Rome-based agencies, IFAD and WFP.

'Good governance' has given way to more pragmatic, problem-driven decision-making. For more than two decades, beginning in the early 1990s, expert thinking in the international development community was predominantly focused on the concept — which then became a political project — of promoting 'good governance'[220]. At the peak of its popularity, from the early 1990s to the late 2000s, the good governance agenda generally prioritized commitments to improving transparency, broadening participation and ensuring social inclusion in deliberative processes, eliminating corruption and promoting institutional reform. Backed by good governance programme lending, enormous investments were made in fostering new standards of financial management and public administration. This work was matched by a comprehensive programme of the World Bank to develop indicators and implement monitoring systems to track governments' progress toward meeting these normative, and highly formalized, criteria of good governance.

The expectation was that, over time, a strong positive correlation would be established between progress toward 'good governance' , as defined by the good governance indicators, and high or improved economic performance. By the mid-2000s, however, it was becoming clear that this

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

expectation would not be met. A key limitation of the good governance agenda was that it was too formal and procedurally oriented to address the complex policy bottlenecks and political conflicts that impede effective governance. At the same time, governments became increasingly less willing to invest in programmes that offered few tangible benefits and were seen as a diversion from more important development objectives.

Finally, over the past decade, the preponderance of expert opinion has moved away from the 'good governance' project in favour of a more modest and pragmatic agenda, defined by a commitment to iterative, bottom-up, problem-solving and experimentalist approaches to improved or more effective governance[221]. FAO has made important contributions to this new thinking by fostering innovation in its own institutional arrangements, particularly the reform of the Committee on World Food Security, which has been recognized by the UN as the premier international and intergovernmental platform for inclusive, multistakeholder engagement on food security and nutrition. It has also articulated and demonstrated the value of important conceptual approaches, such as the governance of tenure of land, fisheries, and forests, and the territorial approach to development, which supports multisectoral governance in local, municipal and regional contexts.

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

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

[221] See, for example, Brian Levy, *Working with the Grain: Integrating Governance and Growth in Development Strategies (Oxford University Press: 2014);* Matt Andrews, *The Limits of Institutional Reform in Development* (Cambridge University Press: 2013); David Booth, *Development as a Collective Action Problem: Addressing the Real Challenges of African Governance* (Overseas Development Institute: 2012); Merilee Grindle, "Good Enough Governance: Poverty Reduction and Reform in Developing Countries", *Governance* 17(4): 525-548; Jomo Kwame Sundaram and Anis Chowdhury, eds., *Is Good Governance Good for Development?* (Bloomsbury: 2012); and Grainne de Burca, Robert O. Keohane, and Charles F. Sabel, "Global Experimentalist Governance," 44 Brit. J. Pol. Sci. 477 (2014).

14 Development finance

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

Achieving the 2030 Agenda for Sustainable Development will require a comprehensive investment approach, one which mobilizes public finance, sets appropriate public policies and regulatory frameworks, unlocks the transformative potential of people and the private sector, and creates incentives for changes in consumption, production and investment patterns[222]. While Official Development Assistance (ODA) will continue to be a critical source of investment in development post-2015, the past decade has seen important changes in the development finance landscape. More funding options have become available, including new development banks, sovereign donors, private foundations, NGOs and specialized funds[223,224].

Financing is the lynchpin for the success of the 2030 Agenda[225]. The overall priority of the 2030 Agenda is the eradication of hunger and poverty. This commitment is spelled out unequivocally in SDG 1, "End poverty", and SDG 2 "End hunger, achieve food security and improved nutrition and promote sustainable agriculture". Food security and its link to natural resources and rural development are inherent to virtually all of the SDGs – for example, conserving and using sustainably the oceans, seas and marine resources (SDG 14), and sustainably managing forests, combating desertification, and halting and reversing land degradation and the loss of biodiversity (SDG 15). A shift to more sustainable consumption and production, which is also fundamental to efficient and sustainable agriculture and food systems, is exemplified by SDG 6 on clean water and sanitation, by SDG 7 on affordable and clean energy, and by SDG 13 on combating climate change.

Achieving the Sustainable Development Goals will require the implementation of a range of measures through country-led and country-specific strategies and processes[226]. The foundation and framework for implementing the 2030 Agenda is provided by the Addis Ababa Action

[222] United Nations. 2015. Financing sustainable development and developing sustainable finance. A DESA briefing note on the Addis Ababa Action Agenda. http://www.un.org/esa/ffd/ffd3/wp-content/uploads/sites/2/2015/07/DESA-Briefing-Note-Addis-Action-Agenda.pdf

[223] OECD. 2014. The New Development Finance Landscape: Developing Countries' Perspective. Working draft presented at the OECD workshop on development finance on 25 June 2014.

[224] United Nations. 2014. Report of the Secretary-General Trends and Progress in International Development Cooperation Development Cooperation Policy Branch Office for ECOSOC Support and Coordination Department of Economic and Social Affairs United Nations. http://www.un.org/en/ecosoc/docs/adv2014/2014_dcf_sg_report_adv.pdf

[225] http://www.un.org/esa/ffd/ffd3/press-release/countries-reach-historic-agreement.html

[226] FAO, IFAD and WFP estimate a requirement of about USD 145 billion in additional investment to achieve zero hunger by 2030 (see paragraph 8).

Agenda,[227] endorsed by 193 countries at the Third International Conference on Financing for Development in July 2015. Considered a turning point in international cooperation[228], the Addis Agenda seeks to tackle a range of economic, social and environmental challenges, and identifies priority areas for the mobilization of public and private resources in support of national development plans[229].

Commitments include taking action to fight hunger and malnutrition, and supporting sustainable agriculture, including forestry, fisheries and pastoralism. The agenda pledges to strengthen efforts to enhance food security and nutrition, with a focus on smallholder and women farmers, as well as agricultural cooperatives and farmers' networks. Recognizing the enormous financing needs in these areas, governments commit themselves to increasing public investment, which plays a strategic role in financing research, infrastructure and pro-poor initiatives, while also encouraging increased private investment[230]. In related commitments, the Addis Agenda calls for the adoption of measures to ensure the proper functioning of food commodity markets and their derivatives, and to facilitate timely, accurate and transparent access to market information in order to limit excessive price volatility. It also calls on World Trade Organization members to correct and prevent trade restrictions and distortions in world agricultural markets.

Zero hunger could be achieved rapidly with a combination of social protection and pro-poor investments. Under a 'business as usual' scenario, global growth in GDP is expected to raise incomes sufficiently to reduce the prevalence of undernourishment to less than 8 percent of the global population by 2030. However, large concentrations of hunger would persist in South Asia (9.3 percent) and especially in sub-Saharan Africa (17.4 percent). In absolute terms, more than 650 million people would remain undernourished in 2030.

Recent estimates suggest that extraordinary income support measures would quickly eradicate extreme poverty and hunger, while a progressive and sustained emergence out of extreme poverty by 2030 could be achieved through a combination of pro-poor public and private investments in more inclusive rural growth and development[231]. FAO estimates at US$67 billion annually the amount needed for social protection programmes that would lift the very poor out of poverty and hunger. Some US$41 billion would be needed in rural areas, where most of the poor live, and US$26 billion in urban areas. Nearly all of these costs could be borne by most middle- and low-income countries, although some of the poorest countries and those facing conflict and humanitarian disasters would require international support.

Social protection helps recipients become more productive by enabling them to manage risks, build assets and undertake more rewarding activities. The benefits of social protection spread beyond the immediate recipients to their communities and the broader economy as recipients purchase food and other goods and services. But social protection can only offer a sustainable

[227] Addis Ababa Action Agenda, Outcome Document of The Third International Conference on Financing for Development in Addis Ababa (July 2015) http://www.un.org/esa/ffd/wp-content/uploads/2015/08/AAAA_Outcome.pdf

[228] http://www.un.org/esa/ffd/ffd3/press-release/countries-reach-historic-agreement.html

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

[230] Addis Ababa Action Agenda, Outcome Document of The Third International Conference on Financing for Development in Addis Ababa (July 2015) http://www.un.org/esa/ffd/wp-content/uploads/2015/08/AAAA_Outcome.pdf

[231] FAO, IFAD, WFP, *Achieving Zero Hunger* (2015), pp. 9-13.

pathway out of poverty if it is complemented by inclusive growth in the economy, and particularly in the rural economy.

To achieve a sustainable end to extreme poverty and eliminate the need for extraordinary public transfers, sustained additional pro-poor investments averaging US$198 billion annually in the period 2016-30 are needed. In the initial stages, much of this investment would provide only marginal benefits to the poor, who earn incomes mostly from labour remuneration. But over time, as poor people acquire the means to save and invest, they would progressively increase their earnings, not only from labour, but also from the remuneration to the productive assets they acquire.

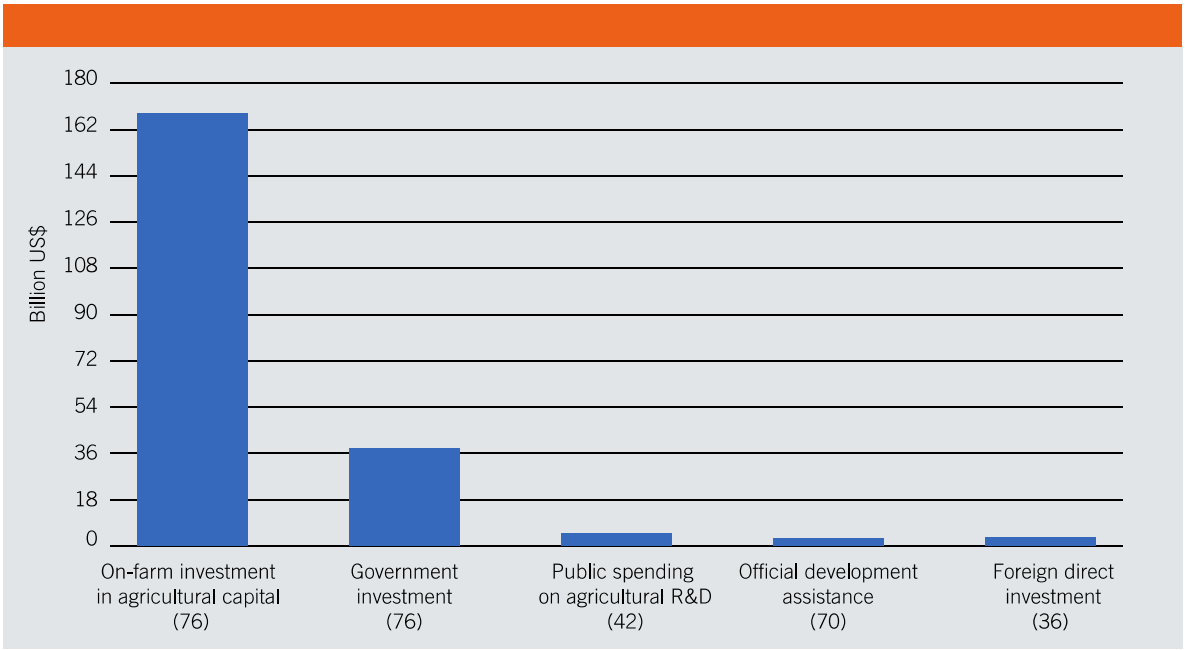
This combination of social protection and pro-poor investment in agricultural and rural development offers synergies that can increase the effectiveness of both, and represents the fastest and most reliable route to ending poverty and hunger. It also requires significant political commitment and strong governance capacities[232].

The role of the public sector in investment is changing. Low-income countries need to step up efforts to finance their own development by improving domestic resource mobilization – for example, by ensuring more effective tax administration, by harnessing public revenues from the use of natural resources through adequate fiscal rules and strong public financial management systems, and by improving their expenditure efficiency. However, *most of the capital for development of the agricultural sector will continue to come from the private sector, and especially from farmers themselves (Figure 14.1).* In order to achieve a transition to sustainable food and agriculture, therefore, governments need to improve the policy conditions for development and growth by *reducing barriers to farmer investment in their own activities and encouraging responsible, larger-scale investment in the sector by private enterprises.*

More than 90 percent of the estimated 570 million farms worldwide are family farms, most of which are under 2 ha in size. At 12 percent, their share of farm land is small at the global level. However it is significant in the low- and lower-middle-income countries, where the share reaches 42 and 31 percent, respectively. If farms up to 5 ha are included, the respective shares are 73 and 57 percent. Therefore, investment by small- and medium-sized farmers plays an important role in contributing to food security, nutrition and rural income in many countries. However, farmers' wishing to invest in their activity face high barriers, including limited access to financial services, technology, inputs and markets; insecure tenure over natural resources; vulnerability to agricultural risks; and market distortions and other constraints stemming from inadequate policies and regulations. In addition, agriculture is only one of several sources of income for many smallholders. Escaping poverty requires not only increased on-farm productivity but also the creation of non-farm employment opportunities through rural development, more efficient labour markets and capacity development of farm household members.

[232] FAO, *State of Food and Agriculture 2015: Social protection and agriculture: breaking the cycle of rural poverty* (2015).

Figure 14.1: Farmers as largest agricultural investors



Source: FAO State of Food and Agriculture 2012. Number of countries covered is shown in parenthesis.

To stimulate investments, governments need to secure property or tenure rights, develop rural infrastructure and public services, and ensure that their institutions are functioning. Government investment in public goods and services – such as institution-building, agricultural extension, productivity-enhancing research, rural transport, health, education and social protection – is fundamental to creating an environment favourable to private investment. A positive recent trend is the emergence of partnerships between the public sector, private sector and communities which promote agriculture and rural development, poverty reduction, food security and nutrition.

Since the availability of public funding at both national and international levels is diminishing, more private investment is needed from agro-food industries as well as from non-traditional institutional investors, such as hedge funds, private equity groups, insurance companies and pension funds. However, there is no clear evidence of increasing investment from these sources in the food and agriculture sectors of low-income countries. This leaves private banks as the main source of financing for smallholder and family farmers, as well as for small-scale rural enterprises. Smallholders invariably face the highest barriers to accessing bank finance, since they usually have limited financial literacy, collateral and credit history, and few other sources of income[233]. Needed are special programmes offering incentives to private (including cooperative) banking institutions to increase their rural coverage. Creation of employment opportunities in infrastructure development and public procurement of small farmers' produce can also help to stabilize incomes and provide opportunities for acquisition by low-income rural people of productive assets such as land, equipment and seed.

[233] FAO. 2016. *The State of Food and Agriculture. Climate change, agriculture and food security.* Rome.

New sources of investment financing are emerging. Available finance for investment in agriculture already falls well short of needs[234]. *As ODA flows decline, especially those directed to middle-income countries, the emergence of non-traditional sources presents an opportunity to fill financing gaps. Recent years have seen the appearance of new financing institutions, such as the Green Climate Fund, established in 2010 under the United Nations Framework Convention on Climate Change to support projects, programmes, policies and other activities in developing countries.* Climate finance could act as a catalyst to leverage larger flows of public and private funding for sustainable agriculture, provided policies and institutional frameworks that promote transformative change are in place. Climate finance could also help address the funding gap by demonstrating the viability of climate-smart agricultural investments[235].

Other emerging investment sources include development banks largely financed by low- and middle-income countries themselves, such the Asian Infrastructure Development Bank, under the leadership of China, and the New Development Bank operated by Brazil, Russia, India, China and South Africa (BRICS), which aims at mobilizing resources for infrastructure and sustainable development projects in BRICS and other emerging and developing economies[236].

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

The need for responsible investment in food and agriculture – which contributes to food security and nutrition, especially for the most vulnerable, and to the progressive realization of the right to adequate food – has also been recognized. In 2014, the Committee on World Food Security endorsed Principles for responsible investment in agriculture and food systems[237]*. A broad range of stakeholders*[238] agreed f*or the first time* on a set of 10 principles that apply to all types and sizes of agricultural investment and to all stages of the value chain. As a soft law instrument, the non-binding principles are globally applicable and include actions to address a range of environmental, social and economic issues.

[234] FAO. 2016. *The State of Food and Agriculture. Climate change, agriculture and food security.* Rome.
[235] FAO. 2016. *The State of Food and Agriculture. Climate change, agriculture and food security.* Rome.
[236] http://www.fao.org/fileadmin/user_upload/FAODG/docs/ENGLISH-BRICS-DECLARACION.pdf
[237] 41st Session of the CFS, 15 October 2014. http://www.fao.org/cfs/cfs-home/activities/rai/en/
[238] Stakeholder groups included governments, United Nations agencies, private sector associations and foundations, civil society and non-governmental organizations, international agricultural research institutions and international and regional financial institutions.